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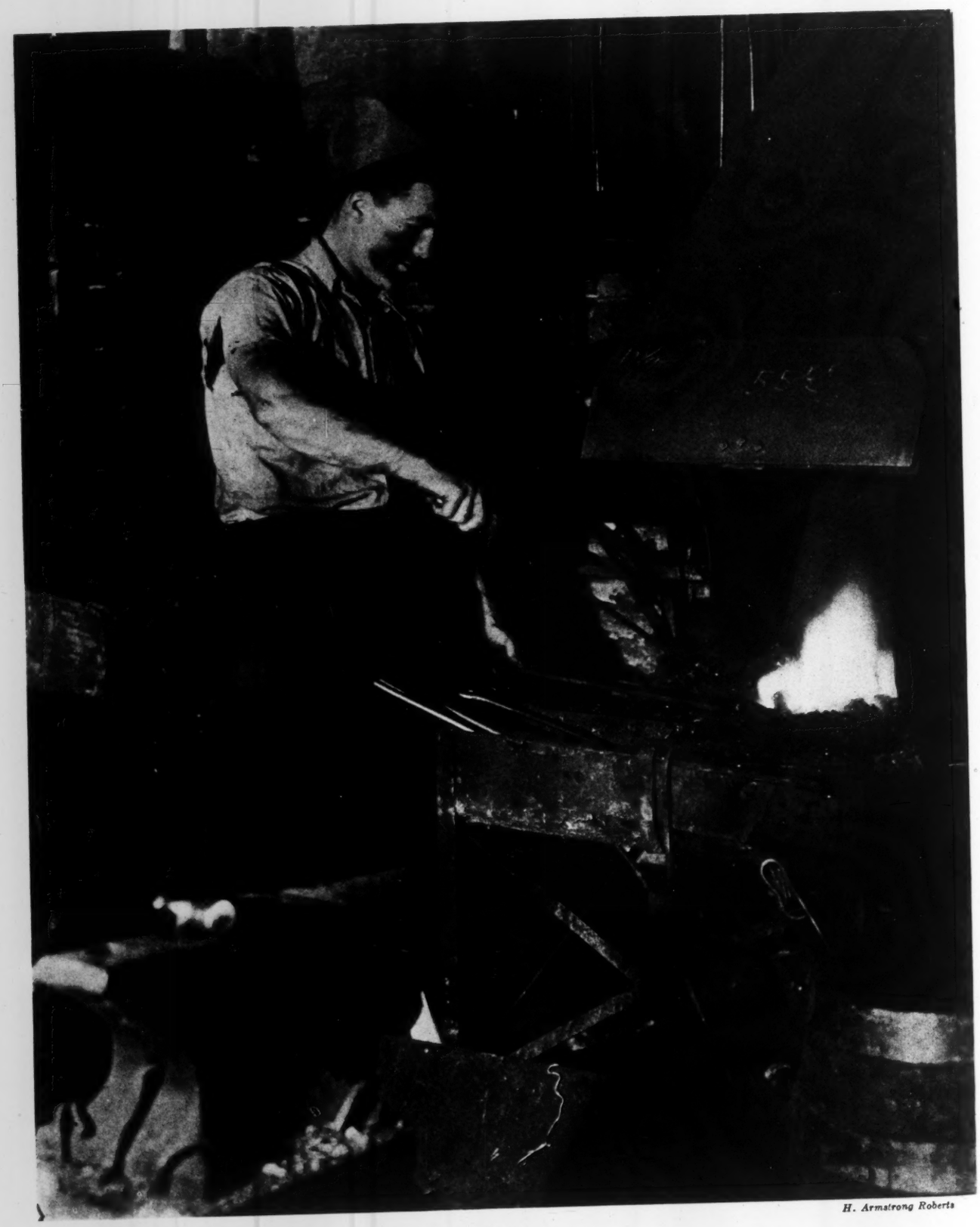


H. Armstrong Roberts

The Craftsman

VOLUME 59
No. 10

MECHANICAL ENGINEERING

OCTOBER
1937

GEORGE A. STETSON, *Editor*

To the Student Member

EVERY YEAR the October issue of MECHANICAL ENGINEERING goes hopefully forth to greet a new body of student members of The American Society of Mechanical Engineers. In a way it is the ambassador of the Society and of the profession—a tangible contact between them and a younger generation. For eight months it competes for attention with classes and professors, and all of those serious and trivial interests that crowd into undergraduate life. After graduation, to those who become junior members of the Society, it will continue to come, month by month, as long as membership is retained. To older men whose life work is past it carries the record of change and progress in their profession, maintaining for them, if they permit it to do so, interests that once were vital. Thus it may become the strongest and most persistent bond between the Society and its members.

To new readers, a word on objectives may be helpful. Material published in MECHANICAL ENGINEERING falls in three broad classes, technological, professional, and Society affairs. Of these, student members will probably understand the first best—it is part and parcel of the subject matter of their engineering education. Except for some comment on student-branch affairs, Society matters lie beyond the student's immediate interest. And as a profession is a point of view—a state of mind, perhaps—the intangible spirit that animates men of more or less common interests and practice—appreciation of what it means comes with maturity, although no one is too young to try to capture it.

A writer in the *Saturday Review of Literature* recently stated that two types of magazine seem to be currently successful—the "look" magazines, made up largely of pictures, and the "digests." Try this experiment. Look at the pictures in MECHANICAL ENGINEERING, and then turn to the digests in "Briefing the Record," page 766. Neither will require painful cerebration until you begin to ponder their significance. Then try some of the longer articles. Professor Roe's article on interchangeable manufacture is easy reading, and what Stevenson and Parker say about the mechanical engineer in the electrical industry will give an excellent idea of what many engineers do day by day. Next try some of the technical papers. Look at the pictures of modern welding in the papers by Wood and Cochrane, and then turn back to the frontispiece. For all you know this craftsman may still be welding a chain link just as it was done hundreds of years ago. What lies between the village smithy and the modern machine shop? More than you think, probably. But some day your generation may make the G. E. shop of 1937 look as archaic as the blacksmith shop of yesterday.

Change, constant change, makes progress and affects the lives of men day by day. Engineers must keep up with it as best they can. MECHANICAL ENGINEERING is designed to help. With constant study change takes on meaning, and trends become discernible. The professional spirit becomes conscious. Langley's whirling machine becomes a symbol as well as a cleverly executed model. Direction attains significance.

The Scientific Research Bill

ON JULY 20 the Hon. Jennings Randolph, of West Virginia, introduced into the House of Representatives a bill, H.R. 7939, known as the Scientific Research Bill, by which it is proposed to set up a Scientific and Advisory Committee and a Scientific Research Commission whose functions would, in general, carry out the suggestions made in the report of the National Resources Committee recently noted in these columns. The bill provides for "the promotion of the general welfare in relation to the economic effects flowing from scientific and technological developments."

Engineers are among those who are likely to be personally interested in Mr. Randolph's bill and in its final provisions if it is reintroduced and enacted. It proposes a step in planning for the future on a scale whose implications are broad and hence inventors and research workers particularly should give it close study.

The proposed Scientific and Technological Advisory Committee is to be an "integral part" of the National Resources Board, and "shall ascertain at regular intervals the occupations and industries which are likely to be affected by imminent scientific or technological changes and the extent to which such developments are likely to result in unemployment or in increased employment," and shall also "ascertain at regular intervals the recent social and economic effects of scientific and technological developments as well as the effects likely to occur in the near future."

The three members of the proposed Scientific Research Commission "shall be men of recognized research ability and experience who are capable of analyzing research problems in scientific fields and of directing research, as

well as evaluating the social and economic effects likely to result from such research."

The bill provides for the filing of plans or projects with the commission by any individual; and "the commission may analyze each plan . . . . from a scientific, an economic, and a legal standpoint" before giving its approval. An approved plan is to be submitted "with the necessary funds for its execution to a research laboratory." There are stipulations regarding the character of these laboratories and compensation for their use. Other provisions deal with patent titles, patent licenses, a "bonus" for inventors and discoverers, and the naming of experts by the Commission to render "opinion evidence" on technical questions arising in patent litigation, if requested by the court or the litigants.

In attempting to correlate scientific and technological discoveries with their social and economic consequences, Mr. Randolph is tackling a confusing problem, but at least he has put something down on paper for friends and foes of planning to shoot at. It would seem that the time for shooting is now and not after possible enactment. Mr. Randolph hopes that the bill "offers a practical method to unite all science for the benefit of human kind," and invites comments, suggestions, and endorsements.

Seed Corn

COMMENT on the late Andrew W. Mellon has centered on his long service as Secretary of the Treasury, his success as financier, the magnitude of his personal fortune and the extent of his industrial interests, and his art collections, a gift to the people of the country with a museum to hold them. But among engineers emphasis is more likely to be placed on what his money and imagination made possible in increasing the wealth of the country through the encouragement of industrial research and the financing of industrial enterprises. In these fields he is remembered as a product of a rapidly expanding technological era, endowed with the talent and discernment required to give thought to the seed corn of industry, without which harvests would be meager and capitalistic enterprise would be faced with starvation.

Whatever unkind thrusts are made at bankers and their alleged conservatism and anti-social attitudes may be principally charged to a nation confused by the greatest depression ever experienced, with the necessity of finding a scapegoat, to personal bitterness resulting from the frustration of hopes and plans, and to differences in judgment. But few will deny that in enterprises undertaken by industry under private capitalism the familiar quintet of ems—machinery, men, methods, management, and money—must be regarded realistically and inclusively if success is to be assured. While we may at times, as at present, give overemphasis to men as a result of recent distress, turn against machinery in the false notion that it creates lasting unemployment, and bring management into question for the same reasons, unless the germs of these famous five are present in the seed corn, the harvest will be disappointing.

Andrew Mellon's influence was with money, and, for the sake of preserving alliterative unity, with methods, since it is with methods that research may be most conveniently classified. It is the importance of these two factors that must be stressed in recalling Mr. Mellon's contribution to our industrial civilization. The banker whose imagination and judgment are strong enough to back new enterprises is a necessary part of national economic life, for without him few can exist under our present system. But when, as in the case of Mr. Mellon and his brother, there is added that service to industry and applied science that provides practical encouragement of research as is accomplished by the Mellon Institute, the debt of society is doubled.

N.A.C.A. Report

IT IS A far cry from Langley's whirling table, which Professor Dent describes in this issue, to the eight-foot 500-mph wind tunnel placed in operation during the past year by the National Advisory Committee for Aeronautics at Langley Field. In the intervening years the history of aviation to date has been created with results which even the most casual man on the street senses, and the performances, which become such commonplace reading in the press and open up such astounding possibilities, rest upon a vast body of research conducted by hundreds of persons all over the world. In few departments of human progress, certainly in no other field of transportation, has research been as important a factor as in aeronautics.

The amount and variety of research in aeronautics is impressively recorded in the twenty-second annual report of the National Advisory Committee for Aeronautics with which are published the 35 technical reports issued during the year. During the fiscal year the committee expended and obligated $1,157,746, of which $775,114 went for personal services and $159,005 for equipment. What results were obtained from these expenditures are presented in the report, a substantial volume of 574 large-size pages.

Although the compression-ignition or Diesel engine has been developed for use in automotive equipment, a successful Diesel aircraft engine has not been developed in this country. Research on engines of this type, however, is being continued by the N.A.C.A. Much work has been done on combustion processes within the cylinder, the improvement of distribution of fuel within the combustion chamber, and with pre-chamber and integral types of combustion chamber. To supply information lacking on altitude performance of compression-ignition engines, equipment has been assembled and investigation started on conditions equivalent to altitudes from sea level to 30,000 ft. Study of the two-stroke-cycle compression engine has been continued. It is thus evident that this type of engine about which popular discussion is most active is being accorded attention.

The Young Mechanical Engineer in the ELECTRICAL INDUSTRY

By A. R. STEVENSON, JR., and E. E. PARKER

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

PROBABLY no other industry in the world offers the variety and scope for mechanical engineering as does the electrical business. Opportunities for employment exist both in departments using mass-production methods of design and manufacture and in others employing job-shop methods as in the manufacture of large turbines. In the past the tendency for electrical manufacturers to employ a large proportion of electrical-engineering graduates has resulted in considerable mechanical engineering being done by electrical-engineering graduates who have been forced by the nature of their work in an electrical-manufacturing company actually to become mechanical engineers. Electrical engineering is so interwoven with mechanical engineering that the electrical engineer must be familiar with mechanical matters, and, vice versa, the mechanical engineer should know considerable about electrical matters. Even in nonelectrical industries, the design of machinery includes application of electric motors and control. In the authors' own company more mechanical engineers are being employed and special courses have been arranged to give them a chance to develop themselves along mechanical lines, as well as to give them a certain degree of training in electrical engineering. Fig. 1 shows the percentage of mechanical-engineering graduates employed for the "test course." Recently approximately one out of three engineering graduates employed is mechanical.

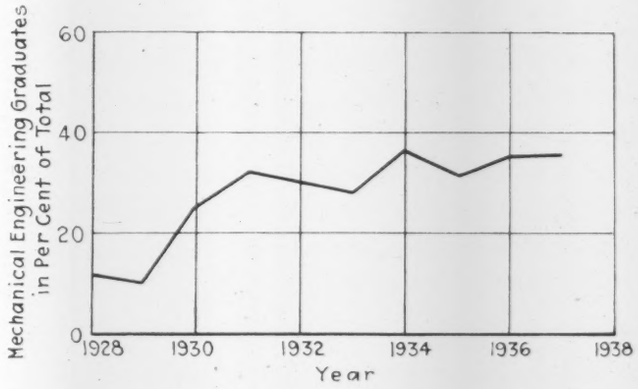


FIG. 1 MECHANICAL-ENGINEERING GRADUATES EMPLOYED FOR THE GENERAL ELECTRIC TEST COURSE EXPRESSED AS A PERCENTAGE OF THE TOTAL NUMBER OF ENGINEERING GRADUATES EMPLOYED

(Since 1931, approximately one out of every three engineering graduates has received college training in mechanical engineering.)

Because electrical engineering is recognized as a separate branch, the fact is sometimes overlooked that the design and manufacture of electrical apparatus involve to a large degree work designated as mechanical engineering. For example, after an electrical engineer has decided on the size and type of punchings and windings to give the proper magnetic-flux distribution and the insulation and electrostatic shields to give the proper distribution of electric potential, someone must do the mechanical engineering involved in designing the supporting structure, determining the heat transfer, the fluid flow of the cooling media, the lubrication, and similar factors. Thus we see that any electrical design requires a large proportion of mechanical engineering. Furthermore, factory processes for construction of the apparatus are also purely mechanical, including tool and die design, coil winding and forming, pattern-making, casting, machining, bending, welding, and the like. Planning for manufacture and shop management and arrangement also are fields for the mechanical engineer.

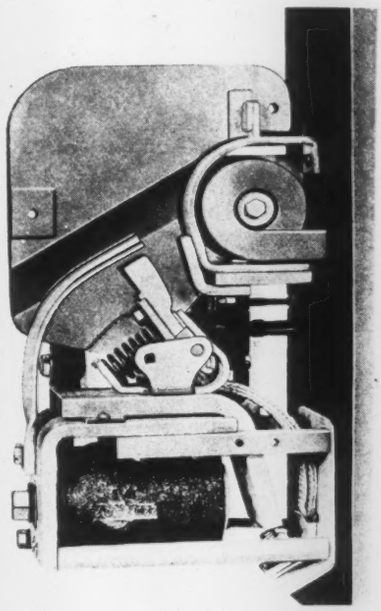


FIG. 2 AN EXAMPLE OF THE DEMANDS MADE UPON A DESIGNER'S MECHANICAL INGENUITY

This is a contactor requiring a mechanical structure in which a solenoid may operate a set of contacts millions of times.)

Electrical apparatus is seldom used alone. It is either driven by mechanical apparatus, such as a Diesel engine, a steam turbine, a water wheel, or other source of power, or it drives or controls a steel mill, a machine tool, an air compressor, or some other machinery. The electrical manufacturer, therefore, must have application engineering departments to study and sales departments to keep in touch with the mechanical industries, so that he can make proper recommendations with regard to the application of electric equipment in those industries.

EXAMPLES OF MECHANICAL APPLICATIONS

The variety of mechanical engineering engaged in by an electrical company extends from the design and manufacture of kitchen mixers, clothes washers, dishwashers, and other household appliances to the design and construction of locomotives and large steam tur-

Contributed by the Committees on Education and Training for the Industries and Relations With Colleges for presentation at the Fall Meeting, Erie, Pa., Oct. 4-6, 1937, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

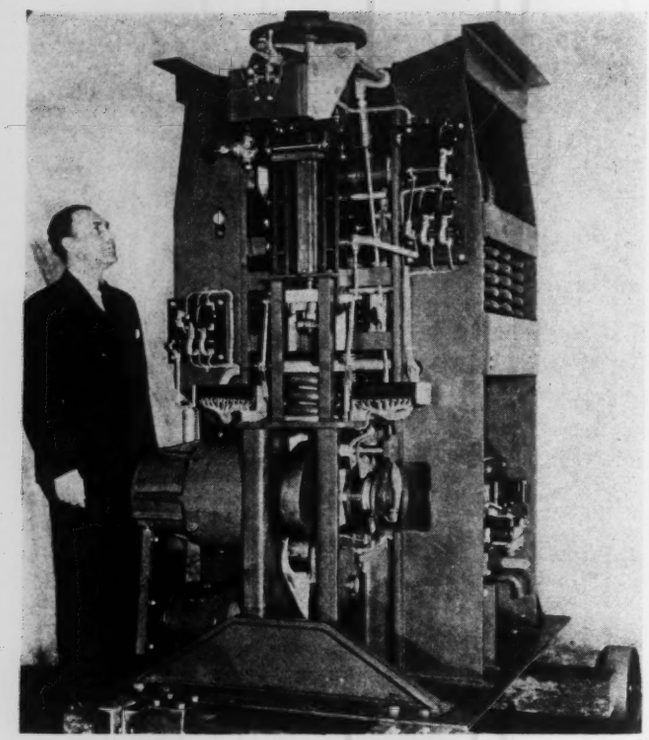


FIG. 3 MECHANISM FOR A 287,000-V CIRCUIT BREAKER INSTALLED ON THE POWER-TRANSMISSION LINE BETWEEN BOULDER DAM AND LOS ANGELES

bines. The purpose of this discussion is to point out some examples from these fields to show where the work of the mechanical engineer is essential.

When one stops to think of it, switchgear and industrial-control apparatus, although nominally classed as electrical apparatus, depend for their success largely upon the mechanical design of the parts. Fig. 2, for instance, shows a control device, a contactor in which the designer's mechanical ingenuity is applied to provide a mechanical structure in which a solenoid may operate a set of contacts millions of times. In Fig. 3 is illustrated the mechanism for a 287,000-v circuit breaker for Boulder Dam service. Compressed springs release a force of 24,000 lb in 0.01 sec when the circuit breaker is tripped, and the mechanism develops approximately 300 hp for 0.06 sec during interruption of a circuit. These springs are compressed by a motor and are released by an electrical impulse; otherwise, the circuit-breaker mechanism is completely a mechanical-engineering job.

Electric meters, transformers, motors, generators, and locomotives require a surprisingly large amount of mechanical engineering in their design. The direct-current, 8000-hp motor shown in Fig. 4 is directly connected to 54-in. blooming-mill rolls in a steel mill. At maximum effort the motor, which is 21 ft wide, 22 ft long, and weighs 488,000 lb, will deliver 2,900,000 lb torque at 1 ft radius. WR^2 of the shaft and armature is 4,460,000 lb-ft^2. In rolling an 18-ton ingot into a roughing-mill blank, the motor may be reversed 21 times in 1 min, and its reversing time from 40 rpm forward to 40 rpm reverse is 2 sec.

In the mechanical design of the 1800-hp, twin-engined, 171-ton Diesel-electric locomotive that is illustrated in Fig. 5, consideration must be given to distribution of weight, strength of parts to carry weight and withstand coupling and road shocks, natural-vibration frequencies of engine-generator units, and mechanical problems connected with design of traction motors, main generators, and control.

The revolving field for a 55,000-kva generator is shown, in Fig. 6, assembled in the high-speed pit for operation at maximum runaway speed of the driving water wheel. Since this speed in some cases may be nearly three times the normal rate, stresses under such conditions may be eight or nine times normal. Mechanical design of a rotor to meet this requirement is one of the most difficult problems encountered in designing such a generator. In Fig. 7 is pictured the stationary part of a thrust bearing, 112 in. in diameter, for a 48,000-kva vertical water-wheel generator which is designed to support the combined rotor weight and water-wheel thrust of 3,000,000 lb.

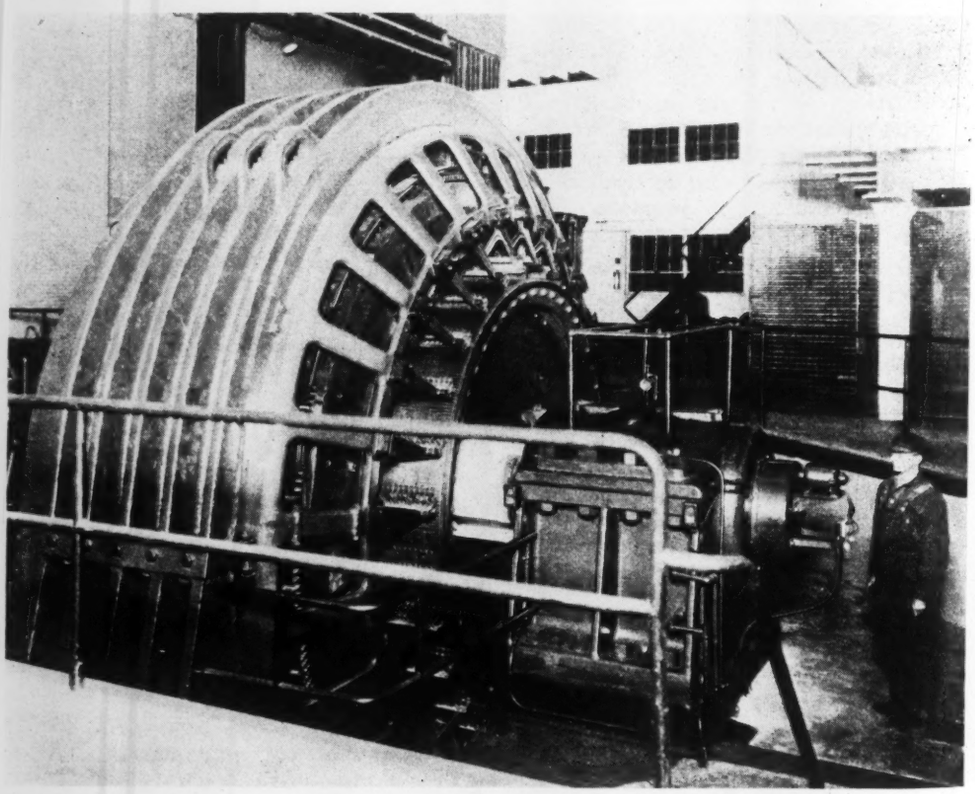


FIG. 4 AN 8000-HP DIRECT-CURRENT MOTOR THAT IS DIRECTLY CONNECTED TO 54-IN. BLOOMING-MILL ROLLS

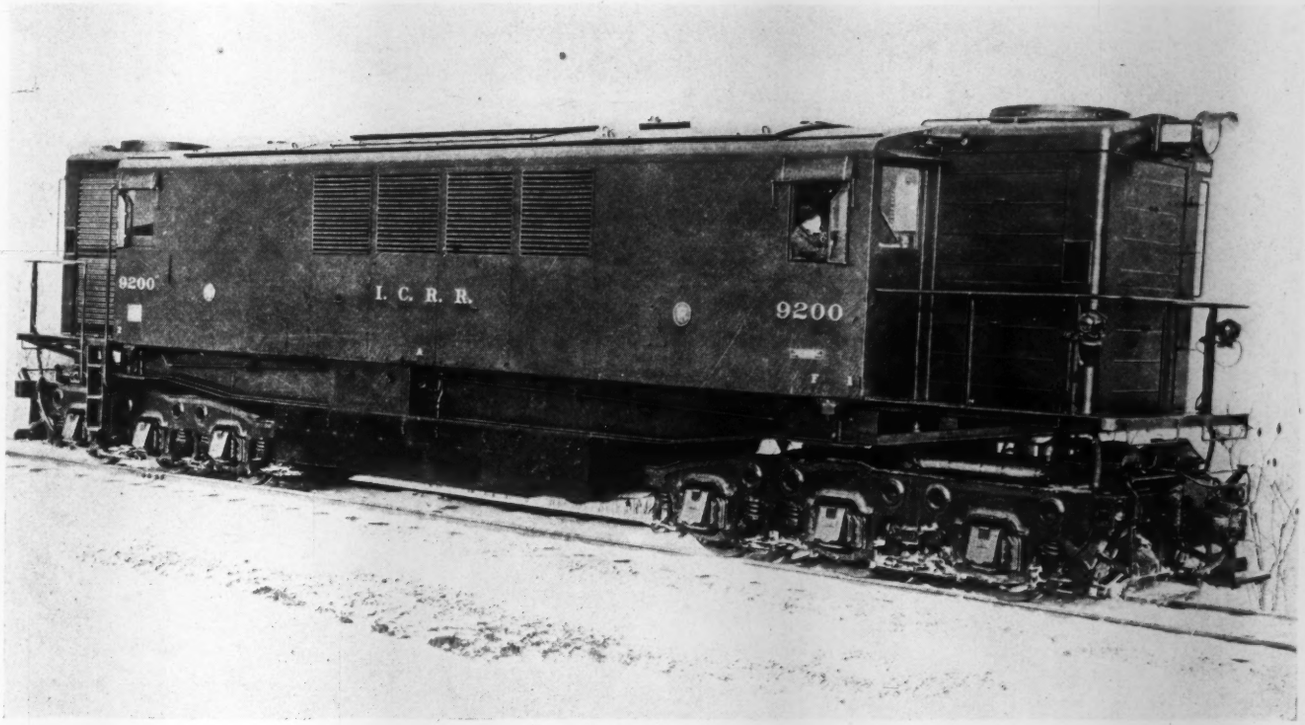


FIG. 5 A DIESEL-ELECTRIC LOCOMOTIVE THAT IS EQUIPPED WITH TWIN 900-HP ENGINES AND WEIGHS 171 TONS

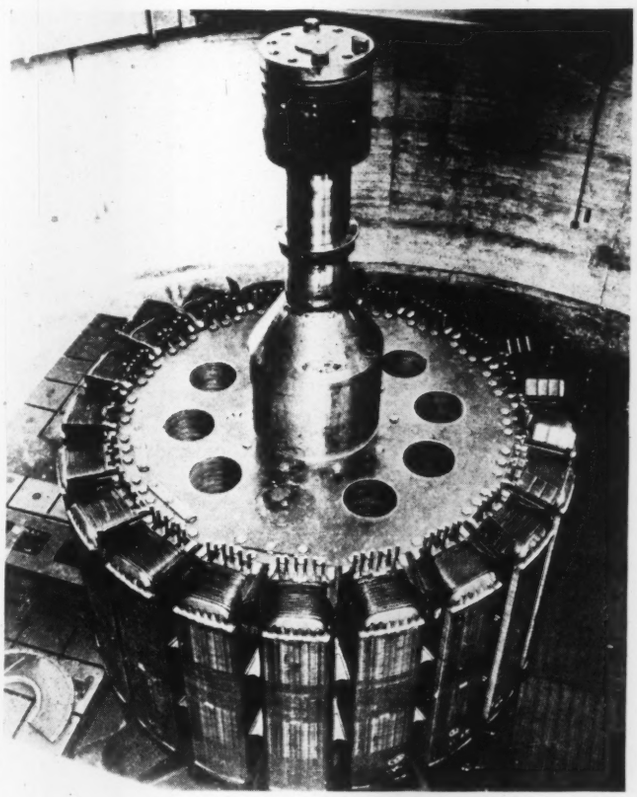


FIG. 6 REVOLVING FIELD FOR A 55,000-KVA GENERATOR ASSEMBLED IN THE HIGH-SPEED TEST PIT FOR OPERATION AT MAXIMUM RUNAWAY SPEED OF THE WATER WHEEL THAT DRIVES IT

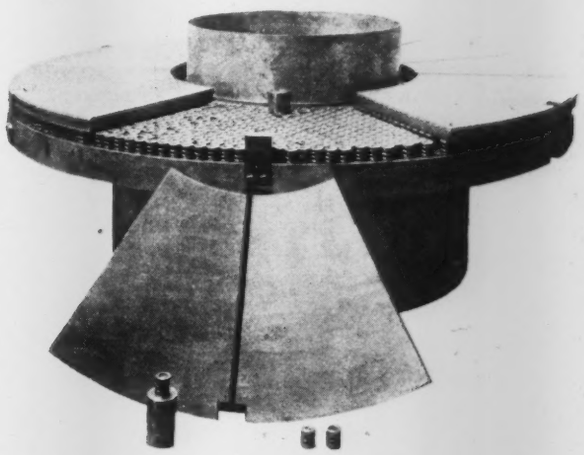


FIG. 7 STATIONARY PART OF A THRUST BEARING FOR A 48,000-KVA VERTICAL WATER-WHEEL GENERATOR

Deflection characteristics of the sectors and supporting springs are coordinated to produce most efficient shape of oil film for maximum load-carrying ability, together with as low a coefficient of friction as possible with a factor of safety that will provide for usual operating contingencies.[1]

The shell of the 25,000-kw hydrogen-cooled turbogenerator illustrated in Fig. 8 is made to withstand a pressure of 80 lb

[1] "A Self-Adjusting Spring Thrust Bearing," by H. G. Reist, Trans. A.S.M.E., vol. 40, 1918, pp. 191–197. Also: "Some Practical Factors Affecting Design and Operation of Bearings for Large Rotating Apparatus," by T. W. Gordon, Pennsylvania State College School of Engineering, Technical Bulletin No. 18, pp. 153–172.

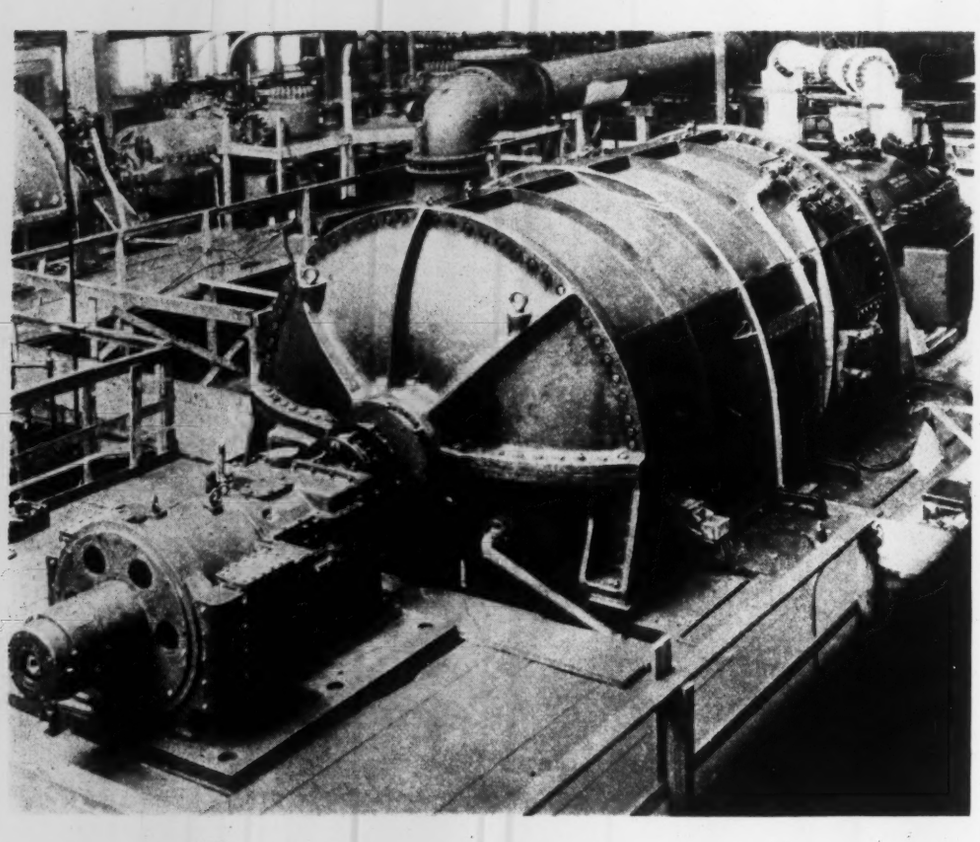


FIG. 8 A 25,000-KW HYDROGEN-COOLED TURBOGENERATOR WITH AN EXPLOSION-PROOF SHELL

per sq in. Hydrogen cooling reduces windage losses to one tenth those of air. Because of better thermal properties of hydrogen, compared with those of air, generator output per pound of active material may be increased 25 per cent.[2] Designing the shaft-sealing gland to prevent escape of hydrogen and inward air leakage represented a difficult mechanical problem. Since the rotor weighs 16 tons and turns at 3600 rpm, balancing must be extremely accurate. A rotor peripheral speed of 29,000 fpm necessitates careful mechanical design so that the parts will withstand resulting stresses.

Most electrical manufacturers also produce a variety of related equipment which is purely mechanical in nature, having been forced to do this to develop the electrical industry to its fullest capabilities. For instance, steam-driven electric generators were limited to about 5000 hp in size because of the lack of a suitable prime mover to drive them until the electrical industry developed steam turbines that could be made in larger sizes. It is the electrical industry that has pioneered the development of the steam turbine from a few hundred to many thousand horsepower.[3]

Turbine design, involving problems in thermodynamics, fluid flow, mechanics, dynamics, and stress analysis, is strictly in the field of the mechanical engineer. Studies in developing, selecting, and testing materials are of great importance in turbine design. Development work on the mercury-steam, binary cycle has been carried on entirely by an electrical manufacturer in cooperation with several electrical utilities. The purpose of this cycle is to obtain a greater difference in temperature between the source and the sink in the cycle and thus increase the efficiency with which heat in the fuel may be converted into mechanical or electrical energy. This project includes development not only of turbines to operate with mercury vapor but also mercury boilers and condensers.

Fig. 9 shows a vertical-compound steam turbine, rated at 110,000 kw, being tested by student engineers in the factory. In Fig. 10 is illustrated a 75,000-kw, 16-stage condensing steam turbine being assembled for factory tests. Each of the 16 wheels must be designed and constructed so that it will not run at a resonant frequency. Buckets on the last-stage wheel travel with a tip speed of 1200 fps, or about 820 mph. Nozzles, buckets, packings, and packing clearances must be designed and built with great care to obtain a turbine with maximum efficiency, capacity, and reliability. The control-valve manifold for a 40,000-kw, 3600-rpm, superposed turbine is pictured in Fig. 11. Steam at 1200 lb per sq in. and 900 F is admitted from the boiler through hydraulically operated emergency stop valves at each end of the manifold and then passes through six control valves, shown in the center, to the turbine.

These control valves are hydraulically operated by a speed governor through oil relays and regulate the steam flow in accordance with the turbine output. In case of loss of generator load, the hydraulic valve-gear mechanism closes the control valves in a fraction of a second to prevent the overspeed governor from tripping and shutting the stop valves, which action

[2] "Hydrogen as a Cooling Medium for Electrical Machinery," by Edgar Knowlton, C. W. Rice, and E. H. Freiburghouse, Transactions of the American Institute of Electrical Engineers, vol. 44, 1925, pp. 922–934. Also: "Hydrogen Cooling of Rotating Machines," by C. M. Laffoon, *Electrical Engineering*, June, 1936, pp. 703–709.

[3] "The Steam Turbine in the United States; I—Developments by the Westinghouse Machine Company," by E. E. Keller and Francis Hodgkinson, MECHANICAL ENGINEERING, November, 1936, pp. 683–696; "II—Early Allis-Chalmers Steam Turbines," by A. G. Christie, MECHANICAL ENGINEERING, February, 1937, pp. 71–82; and "III—Developments by the General Electric Company," by E. L. Robinson, MECHANICAL ENGINEERING, April, 1937, pp. 239–256; see also *General Electric Review*, July, 1937, pp. 331–349.

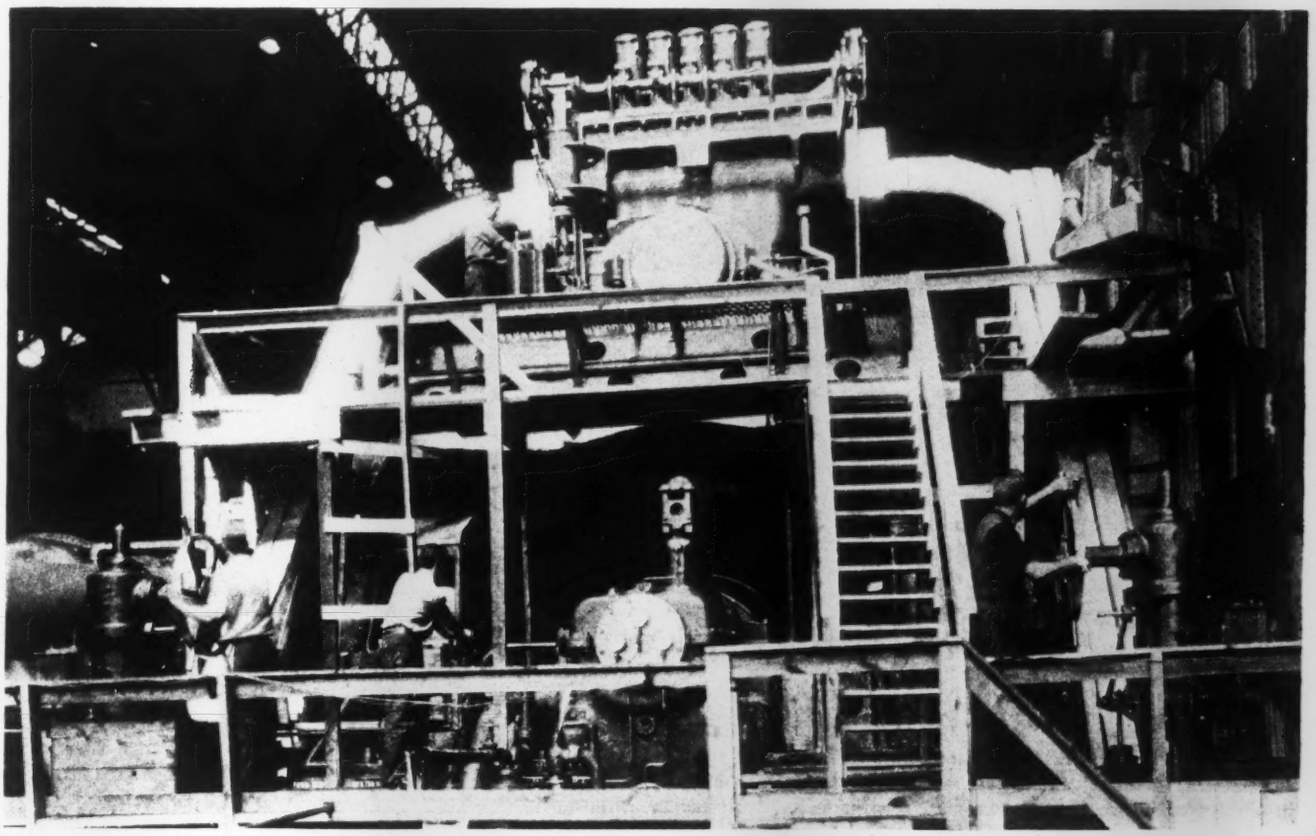


FIG. 9 FACTORY TEST OF A 110,000-KW VERTICAL COMPOUND STEAM TURBINE
(The men testing the turbine are student engineers.)

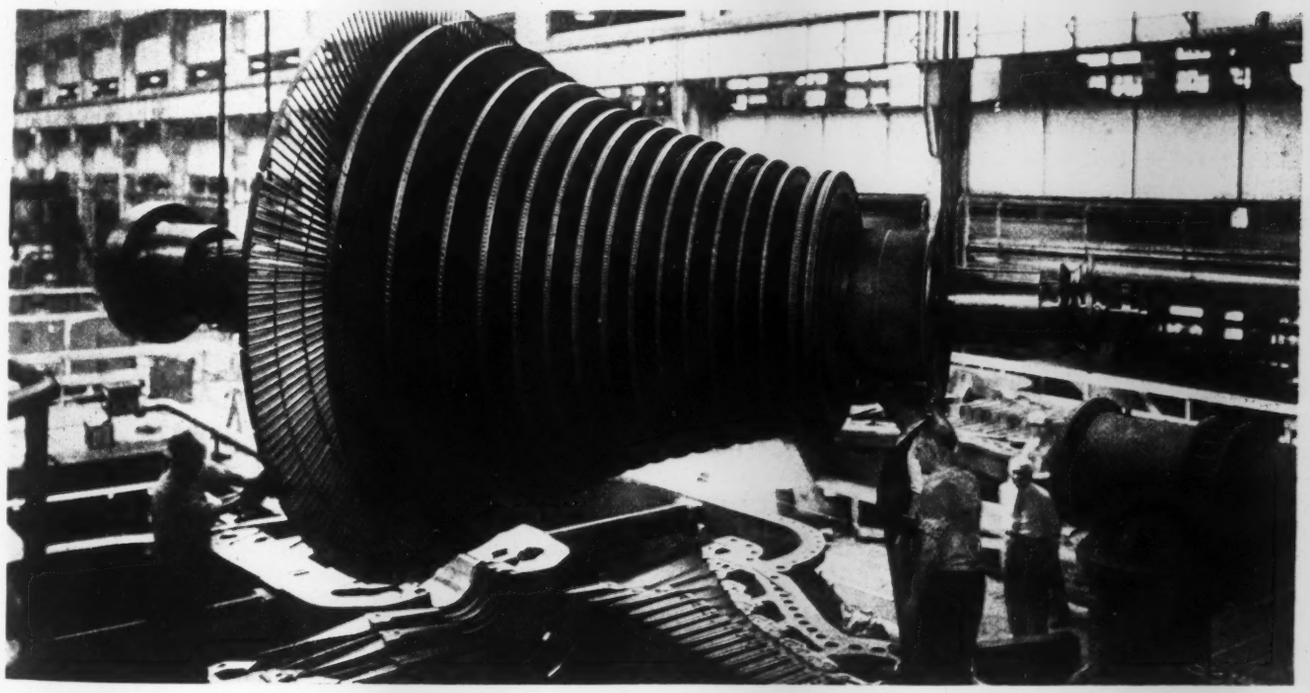


FIG. 10 A 75,000-KW 16-STAGE CONDENSING STEAM TURBINE BEING ASSEMBLED FOR FACTORY TESTS

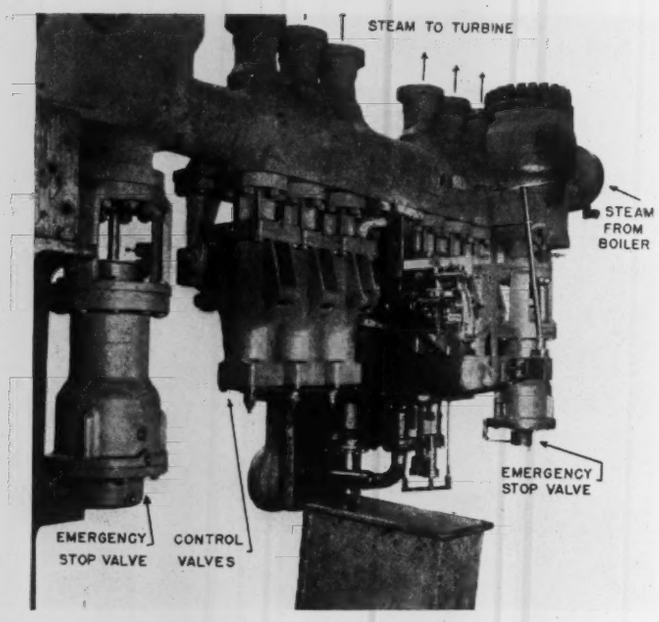


FIG. 11 CONTROL-VALVE MANIFOLD FOR A 40,000-KW SUPERPOSED TURBINE THAT RUNS AT 3600 RPM

occurs at 10 per cent overspeed. With a light rotor, acceleration may be as high as 15 per cent per sec.

Electrical manufacturing companies are among the largest producers of winter and summer air-conditioning equipment. This requires, in addition to the manufacture of refrigeration apparatus, the manufacture of domestic heating boilers and furnaces. The air-conditioning business includes many ramifications of mechanical engineering, as pointed out in a previous article by one of the present authors.[4] In a new type of radial-flow fan for air-conditioning applications, shown in Fig. 12, minimum noise and high efficiency require that all parts of the fan blades accelerate the air uniformly. The perforated section of the housing serves as a sound cutoff. Unique mechanical construction of the fan is required to obtain light weight without sacrifice of sturdiness, as well as accuracy of blade contours and economical assembly and balancing.

Electrical companies are also among the largest refrigerator manufacturers, having pioneered the hermetically sealed machine for household use. They also produce commercial refrigerating equipment in units as large as 50 hp, which may be assembled into groups of several hundred horsepower for specific applications. To obtain economical and quiet service from refrigerant condensing units such as the 50-hp, eight-cylinder, V-type compressor shown in Fig. 13, problems in thermodynamics, heat transmission, fluid flow, mechanics, and dynamics must be carefully solved in designing the compressor, and these must be followed by accurate manufacture of the unit, all of which is mechanical-engineering work.

The domestic refrigerator compressor, Fig. 14, is hermetically sealed in a steel case to preclude oiling, repairs, or even minor adjustments. This arrangement necessitates careful design and manufacture to obtain reliability over a period of years. Because the gaseous refrigerant is in direct contact with the compressor, motor windings, and lubricating oil, unusual problems with materials, insulation, lubrication, and moisture elimination are encountered. Design features include full-pressure lubrication, oil-cooled motor and compressor, self-aligned bearings, acoustic mufflers, dynamic balancing plus spring mounting, and complete unloading of the compressor on starting and stopping.

Electrical companies manufacture gears of the highest quality, superchargers, compressors, and fans, all of which are in the mechanical-engineering field. Superchargers in particular involve many problems in mechanical design and selection of materials for severe operating conditions. An airplane supercharger driven by exhaust gases is illustrated in Fig. 15, with diagrammatic representation of the operating cycle. The turbine wheel, driven by the engine exhaust, operates at about 24,000 rpm and delivers about 100 hp to the blower. Since nozzle box and buckets operate at a bright-red heat and the entire apparatus weighs only about 90 lb, design and construction of this apparatus involves the solution of many complex mechanical problems.

The steam power generating unit described in a recent paper[5] is automatically controlled, and is capable of responding rapidly to large changes in load. An electrical manufacturer, a boiler company, and a meter producer cooperated in carrying out this development.

COURSES OF STUDY

Reference has already been made to the fact that more mechanical engineers are being employed in the authors' own company, and that special courses are arranged for them. For instance, the advanced course in engineering is given to a selected group of engineering graduates and was described in a recent paper.[6] Quotations, from two portions of this article are of interest here:

> During the first few years of its existence, the course was mainly electrical, but as the years went by it was realized that there was great need for similar training in mechanical engineering. Much of the work in electrical design departments required mechanical, as well as electrical engineering, and there were many mechanical-engineering departments such as turbine, refrigerator, and air conditioning. Therefore, the course was expanded somewhat to include the fundamentals of elasticity, dynamics, and heat transfer, and to extend the study of thermodynamics.
>
> Under this program, by the end of the three years the men have

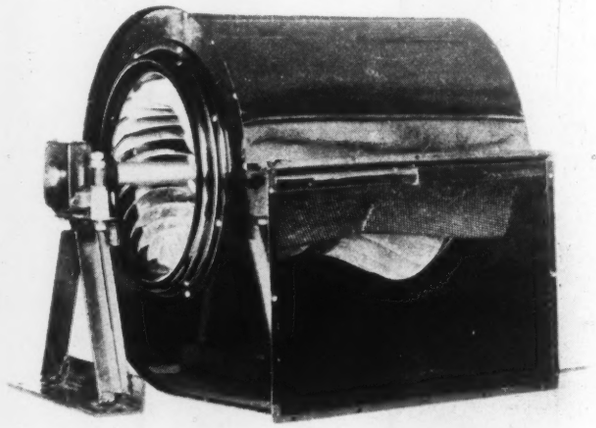


FIG. 12 NEW TYPE OF RADIAL-FLOW FAN FOR AIR-CONDITIONING APPLICATIONS

[4] "Success in Engineering," by A. R. Stevenson, Jr., *Refrigerating Engineering*, May, 1936, pp. 279–281 and 288.

[5] "Steamotive," by E. G. Bailey, A. R. Smith, and P. S. Dickey, MECHANICAL ENGINEERING, December, vol. 58, 1936, pp. 771–780.

[6] "An Advanced Course in Engineering," by A. R. Stevenson, Jr., and Alan Howard, *Electrical Engineering*, March, 1935, pp. 265–268.

received a very thorough training in all of the more important theoretical aspects of machine analysis and design, and have had considerable varied engineering experience. They are well-equipped to solve problems in stresses, machine vibration, lubrication, and cooling as well as those of a purely electrical nature. The men who will go into electrical engineering departments spend about two thirds of the time in the course studying mechanical-engineering subjects. Those expecting to take up more purely mechanical-engineering work receive a very similar training with a little less emphasis on the electrical work.

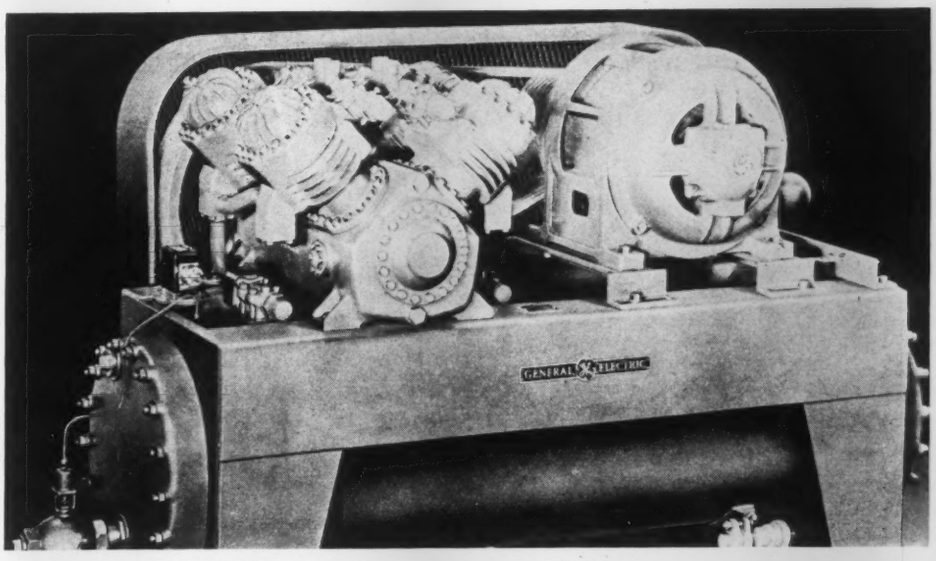


FIG. 13 REFRIGERANT CONDENSING UNIT
(This eight-cylinder V-type compressor, which is driven by a 50-hp motor, provides refrigeration that is equivalent to the melting of 47 tons of ice in 24 hr.)

A complete description of the course will not be duplicated here, but the point should be emphasized that, in the second and third years, the men are placed in various engineering departments on assignments lasting three or four months each, in which they do real engineering work and obtain good insight into the work of the department. This makes a rotating pool of young engineers with fine theoretical qualifications and broad training from which men can be permanently assigned to departments as especially good opportunities arise. They know the departments and the latter know them, and thus selection and placement are put on a much better basis for all concerned. This rotating pool has worked so well that recently another rotating pool has been started to fill the demand for ingenious engineers with design ability who may not necessarily be interested in the technical side which is stressed in the advanced course.

In this second rotating program, the young men have approximately three months' assignments in various departments under the personal supervision of one of the outstanding design engineers in that department. They have an opportunity to see how this older engineer attacks problems and are encouraged to design simpler pieces. They are in contact with drafting room, model shop, toolroom, and factory. During this time, they take a course in which leading engineers lecture on patternmaking, casting, tool design, diemaking, punching, drawing, welding, machine-tool practice, materials, and related topics.

In addition to the advanced course in engineering and the rotating program for mechanical engineers for selected groups, the company offers a general engineering course which is open to any engineering graduate. This course, which is divided into electrical and mechanical sections, gives training in these subjects from the viewpoint of General Electric practice. Young men who are not included in the more specialized courses may enroll in either or both sections of this general engineering course.

It is thus evident that the electrical industry requires a large amount of high-grade mechanical engineering in the design and manufacture of its products. Realizing this, many electrical manufacturers are endeavoring to employ a larger proportion of mechanical-engineering graduates and are arranging courses and opportunities for their development.

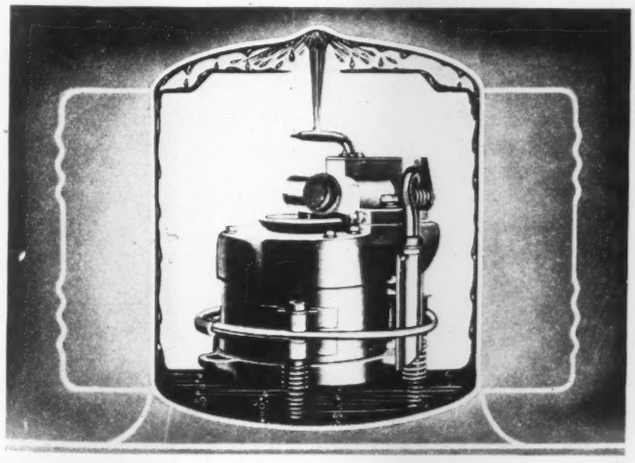


FIG. 14 DOMESTIC REFRIGERATOR COMPRESSOR THAT IS HERMETICALLY SEALED IN A STEEL CASE

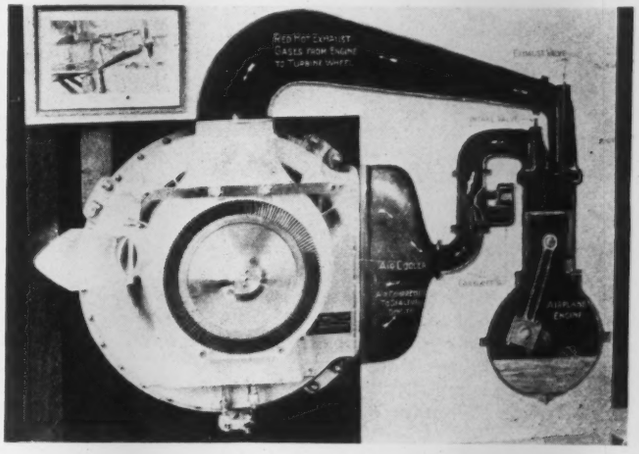
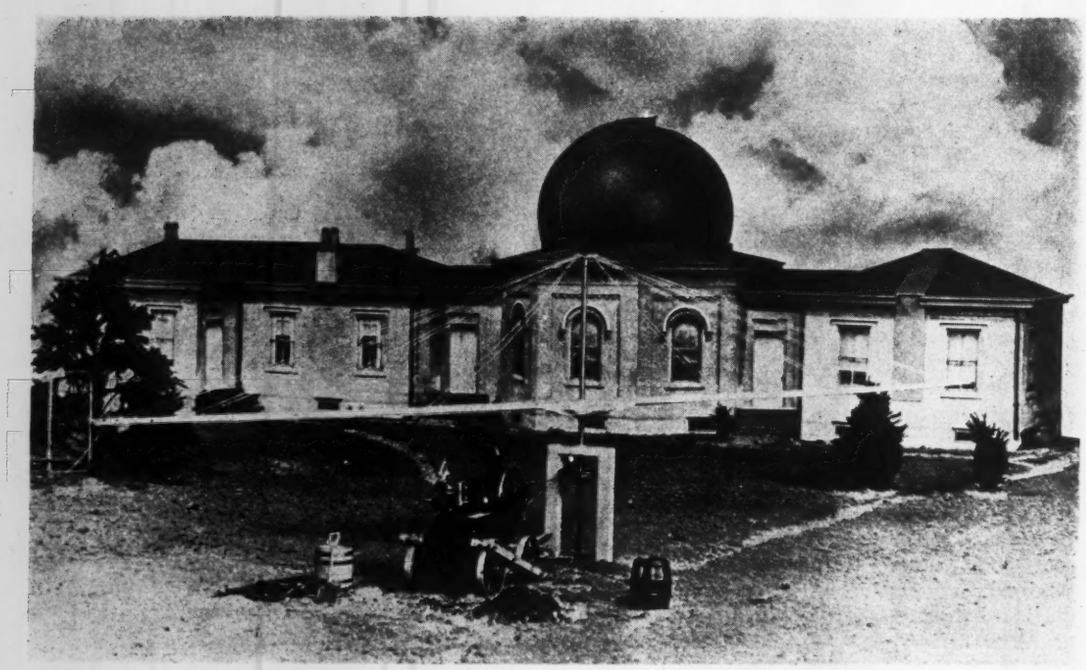


FIG. 15 EXHAUST-GAS-DRIVEN AIRPLANE SUPERCHARGER WITH THE OPERATING CYCLE REPRESENTED DIAGRAMMATICALLY



SCALE MODEL OF OLD ALLEGHENY OBSERVATORY AT UNIVERSITY OF PITTSBURGH WITH LANGLEY'S "WHIRLING TABLE" IN FOREGROUND

THE LANGLEY "WHIRLING TABLE"

By JOHN A. DENT

UNIVERSITY OF PITTSBURGH

IN CONNECTION with the sesquicentennial celebration of the founding of the University of Pittsburgh in June, 1937, it was decided to prepare an exhibit showing the work of Dr. S. P. Langley, professor of astronomy and physics from 1867 to 1891.

The principal feature of this exhibit took the form of a scale model of the old Allegheny Observatory and the "whirling table" used by Professor Langley in his pioneer experiments on the laws of flight. This model is shown in the illustration at the top of this page.

Declaring that "there is no miracle about the flight of a bird," Professor Langley undertook a scientific investigation of the laws of flight and literally lived with his work for many years. The wing of the observatory where he studied and slept is shown at the left in the picture. The results of his researches are indicated in the following quotation from the "Encyclopedia Brittanica:"

> After he had satisfied himself, by experiment with a huge "whirling table" that "it was possible to construct machines that would give such velocity to inclined surfaces that bodies definitely heavier than air could be sustained upon it and moved through it with great velocity," and after studying the irregularities of the winds, he began the construction of several model flying-machines.
>
> He succeeded (May 6, 1896) in launching his "aerodrome" weighing 26 lb and about 16 ft in length, with wings measuring between 12 and 13 ft from tip to tip. It twice sustained itself in the air for about 1.5 minutes (the full time for which it was supplied with fuel and water) and traversed on each occasion over half a mile, falling gently into the waters of the Potomac when the engines stopped. Later in the same year (Nov. 28) a similar aerodrome flew about three quarters of a mile, attaining a speed of 30 miles an hour. Never in the history of the world, previous to these experiments, had any such mechanism, however actuated, sustained itself in the air more than a few seconds. He thus paved the way for others who have achieved success with man carrying machines."

The aerodromes referred to were built in Washington after Dr. Langley left Pittsburgh. A full-size machine designed to carry a passenger and built in 1903 failed due to defective launching apparatus. The same machine, however, was successfully flown by Glenn H. Curtis in 1914.

Thus, Langley (1) established the fundamental laws of flight, (2) built the first heavier than air machines which sustained themselves for an appreciable time, (3) designed and built the first airplane capable of carrying a passenger, though it was not successfully flown in his lifetime. He may truly be called the father of aviation.

THE WHIRLING TABLE

The famous whirling table consisted of a light wooden frame braced vertically and horizontally with guy ropes. It was 60 feet in span and was mounted to revolve about a vertical central pillar. The original drive—an Otto "silent" gas engine—proved unsatisfactory and an old-fashioned steam-driven farm or threshing-machine engine was substituted. This engine drove the whirling table through a quarter-turn belt as shown. With this drive a tip speed of 60 mph, corresponding to about

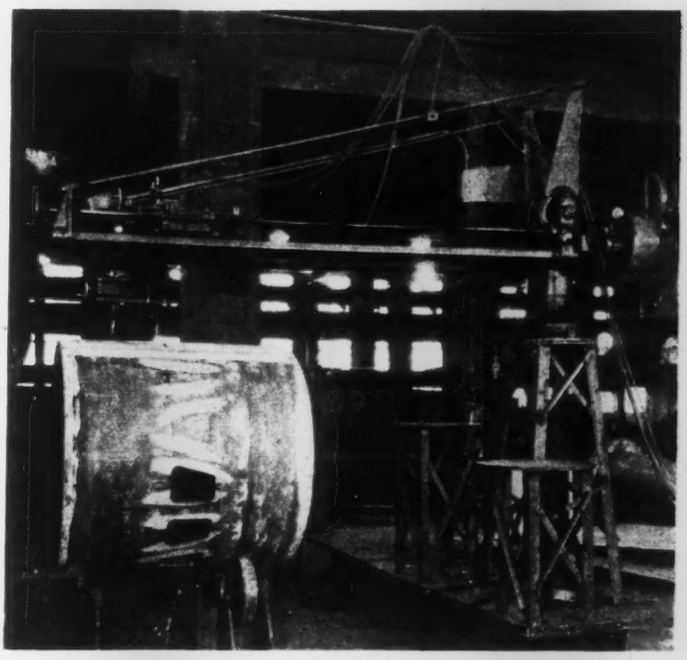
(*Continued on page 714*)

ARC-WELDING PRACTICE *in the* MACHINE SHOP

By A. G. COCHRANE

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y.

FIFTEEN YEARS ago, fusion welding occupied an unimportant part in the average machine-shop setup. Its use was that of a repair tool, and its application was extremely limited because of lack of confidence on the part of engineers and mechanics. To a large extent, this attitude toward the process and its restricted use were caused by lack of information and experience in connection with the proper technique required to produce dependable and consistent welds. In these early stages, the gas or oxyacetylene method was most commonly used for fusion welding. Use of the electric metallic arc has readily advanced and supplanted the use of gas welding, especially in steel-fabrication work, although both methods have their field of usefulness and occasionally overlap to some extent.



UNIVERSAL GAS-CUTTING MACHINE AND DRUM-ROLLING FIXTURE USED IN COMBINATION FOR MAKING SPIRAL CUTS FOR STEAM PORTS IN SURFACE OF TURBINE EXHAUST-HOOD BARREL

(Rotation of barrel controlled by push-button station. Machine torch fed by hand.)

Research work affecting both the arc-welding process proper and the improvement of steel-plate materials and metallic electrodes has been carried out so intensively and successfully in the last 10 years that today the variables which originally caused so much apprehension have been reduced to one, that of the human element, in the case of hand welding, which today is used for the larger percentage of fabrication and welding work. However, methods, through established procedure control in the shop, have successfully overcome the problems and unknown quantities present as a result of this human-element phase. Methods employed in this connection will be explained later.

Today, the machine shop or manufacturing plant has at its disposal, in arc welding, a tool or process now recognized by all trades, designers, and the general public as consistent and dependable. As a result, the economic possibilities and field for steel fabrication have increased to the point where it now is a trade in itself. Yesterday, the machine shop had a small welding division as an auxiliary unit; today, this welding or fabrication unit is one of the most important parts of the same shop, and in many cases it is desirable to have a centralized fabricating department with an auxiliary unit of those machine tools required to produce many of the parts incidental to fabrication work. Final machining operations on such apparatus are performed in the main machine-shop division, which may or may not be a part of the fabricating shop.

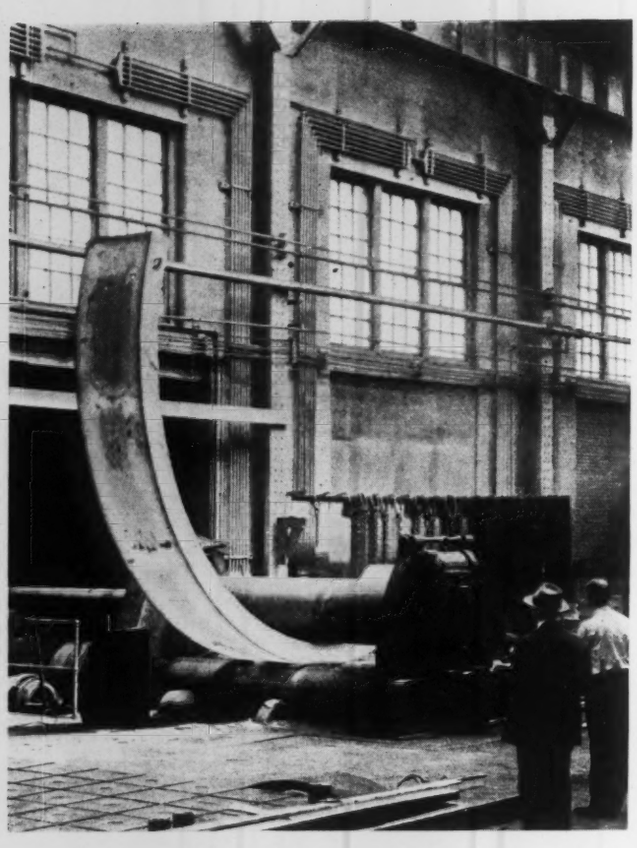
For the purpose of this paper, we shall consider general shop practice as it pertains to welding and fabrication work on large apparatus. Whenever welding is discussed, unless otherwise stated, it will pertain to fusion welding with the electric metallic arc. Before considering actual details of shop practice, we have three important phases of fabrication and welding which must be covered effectively and satisfactorily outside the shop and ahead of actual shop operations if we are to produce dependable apparatus economically. These are efficient engineering and design, proper facilities and methods to insure suitable and consistent raw materials such as steel plate, electrodes, and the like, and an organization and routine established to insure efficient and dependable operators or welders at all times.

Contributed by the Machine Shop Practice Division for presentation at the Fall Meeting, Erie, Pa., Oct. 4–6, 1937, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

DESIGNING AND MANUFACTURING DEPARTMENTS MUST COOPERATE

Experience has shown that the designer must be fortified with the necessary data pertaining to welding to enable him to assume all responsibility for size and types of weld to be called for on a piece of apparatus. Frequently, the drafting organization must have a clear conception of the advantages and characteristics of various welding processes and the inherent differences between bare and heavily coated metallic electrodes from welding-cost and weld-strength standpoints if greatest over-all productive economies are to be realized. Drawings should be made as complete and simple as possible to avoid delays and confusion in the shop. Detail dimensioned sections showing type of butt-weld preparation at each point should be shown. Where a certain construction sequence must be carried out because of the nature of the job or for best conditions in the shop, these steps should be shown on the job drawing in the form of notes.

For designers to carry out the various items previously outlined more effectively, the shop must furnish them clear and understandable data pertaining to the various phases of shop practice common to welding and fabrication. Constant contacts should be made between the shop and design department so that the latter is familiar with all problems that the shop



END SLAB BEING ROLLED TO FORM ARC FOR ROTOR FLYWHEEL FOR WATERWHEEL GENERATOR

experiences in producing a given piece of apparatus. This will enable the designer to consider changes or simplification in design to eliminate such difficulties. These contacts should also furnish many helpful suggestions to the designer, which will result in apparatus of better quality and lower shop costs.

Either the shop or separate departments set up for this purpose should furnish designers with comparative welding and fabrication cost data covering the various welding electrodes, processes, and procedures and complete information covering welding preparation, physical properties of the different welds, and processes. They should establish a uniform system of drafting practice to be followed in indicating the class of weld required on job, size and type of weld, and similar information.

SECURING PROPER MATERIAL AND PERSONNEL

Consistent and dependable materials must be obtained to provide proper welding conditions and insure high-quality fabricated apparatus. This function of manufacturing operations can best be handled through an organization such as a laboratory or metallurgical department which carefully prepares detailed specifications under which each type of material is ordered. This organization also carries on periodic or necessary tests to assure receipt of correct and satisfactory materials. The purchase of welding electrodes must receive the same consideration, and the type chosen will depend on the material to be welded, job requirements, and the like. At present, practically all fabricated structures are made up of low-carbon steel. To insure best welding conditions, the carbon should be under 0.30 per cent. Content of phosphorus, sulphur, and other impurities must also be carefully controlled. Application of alloy steels of higher physical strengths with corresponding decrease in necessary job weights is being extended, and much research work is being carried out to establish proper welding methods and electrodes.

Providing efficient and reliable welding operators should be a joint responsibility of the personnel or employment, and the laboratory or metallurgical, departments. Such men must, through experience or training, be capable of making high-quality welds, but since the human element in welding occupies a more important position than in the other trade lines, each man's ability must be determined before placing him on the job and periodic qualification or check tests or a training routine established to insure consistently good work from month to month. Definite changes in materials or electrodes used in fabrication operations frequently necessitate requalifying all men to be employed on this new work or process. The length of time required to train an inexperienced man to do satisfactory welding will depend on the nature of the work and the flexibility required of the man in each case. Arc welders who are versatile enough to use bare and heavily coated electrodes in flat, vertical, and overhead positions require 18 months' training and experience on the average to produce dependable welds that are of good quality and appearance.

PREPLANNING AND PRICING OPERATIONS

From a manufacturing or shop standpoint, one of the most important phases in fabrication and welding as in other lines of work is careful preplanning and pricing of the various operations to be performed. The planning department handling this work must be a balanced group of experienced men who are familiar with all shop conditions and facilities and capable of breaking the job down by operations to insure most effective use of the most efficient methods with resulting lowest shop costs.

This group must consider the following items: Method of producing detail parts, e.g., machining or gas cutting, and if the latter is to be used which type of gas-cutting machine or method could be used to produce the parts most economically; methods to be followed in assembly operations and their sequence, use of subassemblies, and possible use of assembly jigs and fixtures; welding process or type of electrode necessary or best suited to meet job requirements; use of machine or hand welding; use of alternating or direct current; possible savings by incurring handling costs to position work for welding and allow use of larger-diameter electrodes and higher currents as against welding in normal position with smaller electrodes.

Some of the more important of these items will be discussed later, but judgment, knowledge of the trade, and mechanical ability on the part of each planner are necessary to secure the most efficient and economical methods of producing a welded structure. Frequently, on new and intricate designs, a preliminary round table between planners, designers, and interested foremen is necessary to obtain best manufacturing conditions. The planning department is usually in a good position to coordinate data, maintain contact with the design section to effect changes in design, and furnish it data on shop practice, costs, and related topics.

The planning department's responsibility for pricing a job requires collecting and establishing reliable data on each type of operation common to fabrication and welding, especially where piecework or controlled daywork systems of job payment are used. Methods of arriving at piece prices for welding operations may be carried out either on a linear-length (footage) basis or weight-of-weld-metal basis. The former appears to be more flexible and best when considering fillet welds; while pricing data for butt welds, worked up on the basis of

cost per cubic inch, has an advantage, since all that is necessary is to establish table values for the areas of standard V- or U-weld preparations and to multiply these by the length of the joint and then by the established price per cubic inch to get the job price. All basic welding-table figures, of course, should be established preferably by actual job time studies, although, if various incidental allowances for changing electrodes, cleaning, personal and fatigue allowances, handling, and similar contingencies can be accurately established, the possible volume of metal deposited under proper welding conditions in any unit of time can be determined exactly and a reliable welding table established for each type of job and welding electrode. Use of automatic integrating arc time meters simplifies welding-job time-study procedure and provides an accurate means of recording the actual time that the operator is depositing weld metal.

VARIOUS METHODS OF PRODUCING PARTS

Time can well be devoted to a detailed consideration of those items of procedure and choice of processes which have just been outlined as part of the planning job in a welding shop. Primarily, all of us interested or engaged in any manufacturing enterprise must constantly be alert to methods of improving the quality of our apparatus and at the same time strive for lowest possible costs. The application of welding is so flexible that it allows us to reach our productive objective in several ways. One of the first items we must consider is the best means of producing the various detail parts making up the completed job. Such parts generally are composed of irregular shapes or formed sections.

Fabrication and welding today have no more valuable tool at their disposal than gas-flame cutting. Intricate and complicated mild-steel shapes can be produced economically and accurately by this method. Steel sections up to 24 in. thick can be cut by torches using either acetylene, hydrogen, or illuminating gas as a preheating medium, and oxygen for the actual cutting. The mechanics of such cutting is simply a chemical reaction between the oxygen stream and the steel, and the process is not critical on the general run of steel used for apparatus-fabrication work.

Wherever possible, such gas cutting should be done by the machines that are best suited for the job to insure uniform and accurate shapes. Illuminating gas at approximately 1 lb per sq in. pressure, while lower in British thermal units than the other preheating gases mentioned, is entirely satisfactory for machine cutting when torches are equipped with suitable cutting tips and the correct cutting oxygen pressure is used. Acetylene or hydrogen should be used for hand cutting operations to obtain the best results. Recognized maximum shop-run tolerance for good gas cutting is $^1/_{16}$ in. per cut.

Forming of miscellaneous parts is done by conventional machines such as bending rolls, bending brakes, and power or hydraulic presses.

MACHINE AND MANUAL WELDING COMPARED

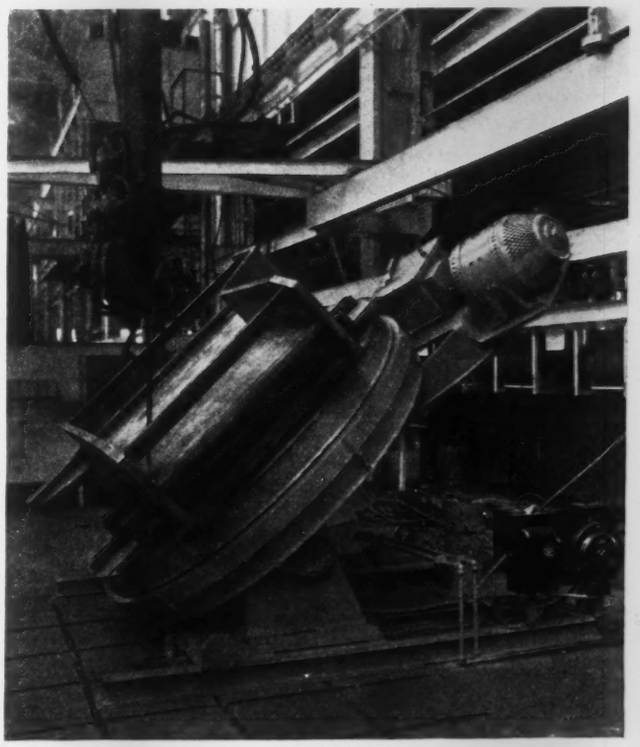
When considering the best method of welding, or in the case of arc welding the type of electrode best suited for the particular apparatus, many factors must be considered. The welding may be done either manually or by machine. In a job shop producing heavy apparatus, use of the latter method entails large expenditure for equipment. The flexibility required to make such machines applicable for producing various types of weld under different job conditions is obvious. A shop wishing to take advantage of machine-welding economies must have straight-line and circular machine-welding equipment. The latter may be the table type which moves the job in relation to the automatic welding head, or the gantry type where the welding head moves along the stationary job part.

Where the nature of fabrication jobs is such that machine welding can be used, excellent economy and results can be obtained. Possible increased welding current with a given-size electrode provides average savings in welding cost up to 50 per cent. Quality and weld appearance are also better than in hand welding. However, as with other machine tools, machine welding involves setups, and on certain jobs and conditions this method cannot be used economically over hand welding and its application must be carefully considered from this angle. In most cases, short welds on large apparatus cannot be made economically by the machine method. Machine-welding equipment to be most economical and efficient must also be served by suitable job-positioning fixtures or equipment to effect best utilization and allow use of maximum allowable welding currents. Various types of positioning equipment are in use; those constructed so that they can be tilted mechanically provide advantages for loading and reduce job-handling time materially.

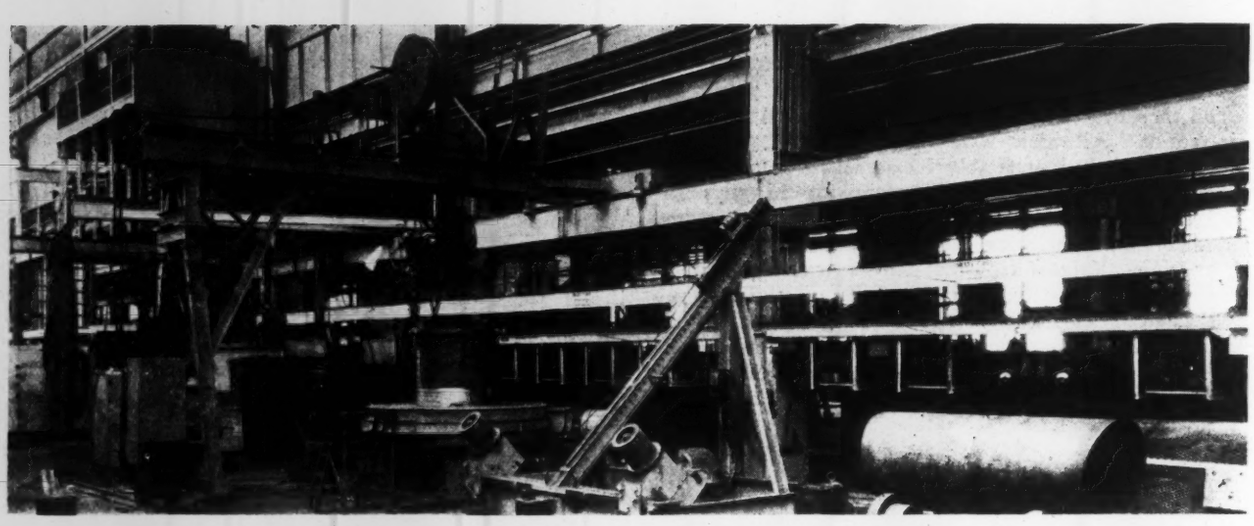
FACTORS INFLUENCING CHOICE OF ELECTRODE TYPE

Choice of arc-welding electrodes depends on job requirements. The use of heavily coated electrodes has increased rapidly in the last five years and in many shops has supplanted the bare electrode entirely. Certain jobs, such as pressure vessels, require heavily coated electrodes to produce welds to meet engineering or welding-code specifications. The weld metal deposited with heavily coated electrodes is superior to that of bare electrodes; e.g., 15 to 20 per cent increased tensile strength and 40 to 50 per cent increased ductility can be obtained.

Although all-purpose heavily coated electrodes are in use, generally speaking, proper positioning of jobs for welding has a greater bearing on effecting economies with this type than



SHOWING ELECTRIC CONTROL OF 7-FT POSITIONING MACHINE, TILTED



GANTRY-TYPE MACHINE ARC WELDER

(Capacity, 40 × 18 × 11 ft. Welding speeds $2\frac{1}{4}$ to 8 in. per min. Push-button control. Note portable fixtures which may be used with this machine.)

with the various bare or lightly coated types. Welds made in this manner are also of better appearance and quality and more uniform. The problem of job-handling time to make proper positioning possible depends on shop facilities, type of apparatus being welded, and similar factors, and often more than offsets that gained through the use of larger-diameter electrodes, increased currents, or both.

Inherent electrode characteristics such as melting rate and over-all deposition efficiency play an important part in ultimate job welding costs and warrant careful study and consideration in steel-fabrication operations. Naturally, their use is desirable from an economic standpoint because of the reduction in welding time that is possible through use of larger-diameter electrodes, $\frac{5}{16}$ in. and over. However, experience in the shop has shown that, when these larger electrodes are used, the process becomes more critical, and greater stress must be placed on the use of proper welding technique to insure high-quality welds, especially from the standpoints of porosity and slag inclusions. This characteristic is less serious with heavily coated electrodes than with the bare type, but its presence must be recognized in all arc-welding operations.

USE OF ALTERNATING CURRENT FOR WELDING INCREASING

Today, we find an increasing use of alternating current for welding operations in place of direct current. The former method has definite advantages and, like every process, certain limitations. Unstable arc characteristics when used with bare electrodes restrict its use somewhat, but, with the trend toward heavily coated electrodes, this is not a serious disadvantage. Alternating-current welding permits increasing welding-current values for a given electrode from 15 to 25 per cent with a corresponding increase in weld-metal deposition. Elimination, through its use, of serious arc disturbance or "magnet action" which is characteristic of direct current and so troublesome under certain job conditions is also a decided advantage. This advantage permits use of larger-diameter electrodes and high currents and thereby provides further possible reduction in welding time over the older direct-current methods.

Lower welding-power costs are possible through use of welding transformers. The extent of such savings depends on the type of direct-current welding equipment that such alternating-current units replace.

Much time has been given to that phase of our subject ahead of or incidental to actual shop-production work. Before considering the practical side of fabrication and welding in the shop, we must assume that our facilities are suitable for such work. Perhaps the most important item in this connection is the type of floor used for the assembly of large, intricate structures or apparatus. Slotted cast-iron floor areas in which the entire surface consists of sections leveled, bolted together, and grouted on a good concrete base are absolutely necessary for best manufacturing conditions. Such a surface provides a true base for the assembler or set-up man, enables him to clamp his parts rigidly during assembly, and acts as a common ground for all welding operations. An installation of this sort is more effective and flexible than individual set-up tables. Large, true layout or inspection plates are also important in the fabrication shop.

CONTROL OF SHOP PROCEDURE AN IMPORTANT FACTOR

During construction and welding operations in the shop, experience has proved that certain steps must be followed to insure best results. For instance, while often it is desirable or necessary to build a piece of apparatus using finished subassemblies, generally a better welding job is obtained if all parts of a given piece of apparatus are assembled, properly tack welded, and stiffened by temporary members or beams prior to any major welding operations. Such procedure insures a complete, rigid structure less susceptible to changes during welding. Job dimensions are more easily maintained, and the necessity for later rework or corrective operations is eliminated. Another important item during assembly operations is that of good fits between parts. Frequently, stock must be removed by hand gas cutting or chipping or added by welding on the edges of parts to provide what is commonly known in the fabricating shop as "metal-to-metal contact." Good fits between component parts eliminate serious changes or distortion during welding and minimize weld failures. Also, most of the natural operating compression stresses to which parts are subjected in the field are absorbed largely by the members themselves and not entirely by the weld.

Recognition of the part the hand welder or the human element plays in general welding operations and the difficulty of determining the quality of welds by visual inspection after

completion, have made necessary the establishment of suitable procedure control involving the welding technique to be followed in actual welding operations. Welding stations or operator sets must be provided with reliable ammeters and voltmeters to insure use of proper currents and arc length. Reference sheets giving the proper welding current range for each type of electrode should be posted throughout the shop to aid the operator. Responsibility for finished welds can be tied down to individual operators by furnishing each with steel stamps with which he stamps the job at regular intervals at a point adjacent to the weld and immediately upon completion of it. Definite assurance of sound welds is provided in the case of pressure vessels and other important structures by X-ray examination. Equipment now available for this purpose clearly reveals weld defects in plate thicknesses up to 4 in. Spot production welding job checks using this method can be carried out very effectively on less important welded apparatus and have an excellent psychological effect on the welders doing such work. Several other items pertaining to the procedure control of welding operations in the shop are outlined later.

The welding steps on any structure should follow a planned and established sequence to minimize final job distortion or weld failures. Reference welding-sequence sheets covering each type of representative apparatus should be compiled and posted in the shop for the operators' benefit and to insure proper welding procedure. This practice has been very successful especially where welding applies to heavy, rigid sections or apparatus.

In the welding field the advantage of welding inspectors on the job has been recognized. No better means can be provided in the shop to insure good welds. Experienced inspectors constantly moving about the floor observing actual welding are in a position to correct many bad habits of technique which welders frequently develop or fall into, and to see that established shop procedure is being observed. They should check such items as proper electrode size and type, welding current, and arc voltage, and see that the welds made are up to size, and that proper preparation on butt or special joints has been provided prior to welding. Such men are invaluable in any welding organization, assist supervision, and are in the best position through contacts and observation on the floor to suggest and apply corrective measures to remedy welding difficulties as they are encountered.

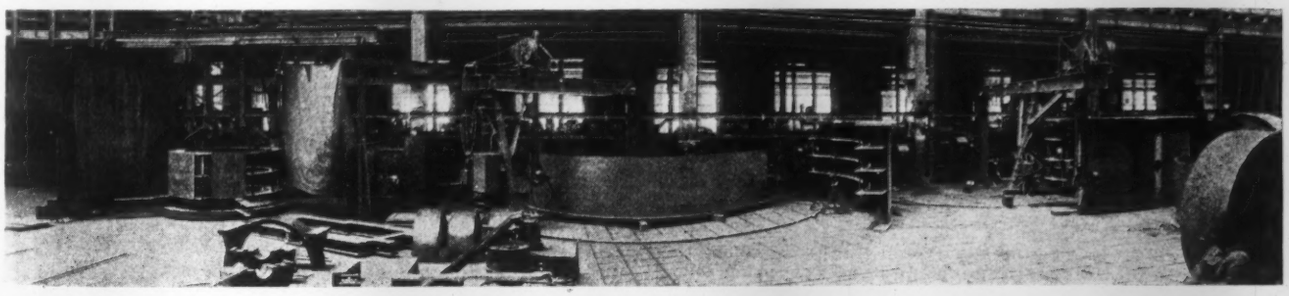
PROBLEMS CAUSED BY DISTORTION AND WELD FAILURES

Under shop problems peculiar to fabrication and welding, the two major items are distortion and weld failures. In one respect, the two are closely related in that local stresses and job changes caused by the heat of the arc, contraction of weld metal on cooling or both show up either as distortion in the case of light structures or occasionally as weld failures where heavy, rigid members are involved. A better appreciation of this relation might be had if we would recognize distortion or deformation as that condition or result where the job members themselves have absorbed stresses or changed shape because of local stresses set up by the welding heat. A job of this type may or may not be subjected to locked-up residual stresses, depending on design, type of structure, and like factors. When such deformation is restricted because of inherent stiffness of design or use of heavy plate sections, thereby permitting no freedom of movement between members, these same local weld stresses must be absorbed by the weld itself. In some cases, they exceed the ultimate strength of the weld material and result in failures.

The metal trades have long known the natural effects and probable results of localized heating. The solution of such problems in welding must be attacked analytically, and best results are obtained by carefully following out the various items of proper procedure control mentioned earlier in this paper. Frequently, steps can be taken in advance of welding to compensate for natural distortion. For instance, we know that, when two members are joined end to end by a butt weld and these parts are free to move together but are kept in the same plane, the over-all length of the two pieces decreases at the rate of $^1/_8$ in. per in. of plate thickness. It becomes a simple matter under such conditions to increase our original dimensions accordingly to obtain the necessary finished dimension. The most effective method of eliminating or controlling weld failures, where unusual job conditions require special treatment, is that of preheating and holding the entire job at uniform temperatures of from 150 to 300 C during welding and slowly cooling.

Recognition of possible existing stresses in certain types of structure as a result of welding makes it necessary in many cases to resort to strain-relief annealing to insure finished apparatus that will not change after final machining operations and will give satisfactory operation in service because residual stresses are absent. Such practice is generally followed on parts subjected to dynamic operating stresses, such as rotating members and those static members made up of extremely heavy sections. The accepted annealing cycle for this purpose involving mild-steel structures is heating to a maximum of 650 C at a rate not to exceed 50 deg per hr, holding at this temperature for approximately 1 hr per in. of maximum stock thickness, and cooling the furnace to 100 C before exposing the piece to normal room temperature.

The various phases of shop practice explained here give a general picture of those factors which must be considered in fabrication and welding operations. No trade or process allows more flexibility in design and manufacture, and few provide the interesting phenomena and field of possibility and research. These facts account for the unusual advance and increasing applications being made of fabricated and welded construction in modern industry and manufacturing operations.



AUTOMATIC CIRCULAR ARC-WELDING EQUIPMENT

Left, 18-ft turntable type; center, 30-ft gantry type; right, 45-ft gantry type.

BIG BUSINESS *in the* UNITED STATES

By HAROLD A. FREEMAN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

THE FIRST two volumes of the Twentieth Century Fund's comprehensive study of big business in the United States have made their appearance. In this review we shall comment only on the first[1] and discuss some of its data together with comparable information presented in an earlier study of the same problem by Adolf A. Berle, Jr., and Gardiner C. Means.[2]

AMERICAN CORPORATIONS

The history of the corporate form in America is briefly summarized. Up to 1800, 335 profit-seeking corporations were organized in the United States and of these 219 or 65.4 per cent were of the highway, canal, and bridge variety. Only 13, or 3.9 per cent, were business corporations and of these 13 only 6 (in the Berle and Means classification) could be called manufacturing corporations. By 1860 railroads had taken over leadership; by 1900 the corporate form of organization completely dominated the field of public utilities (as it does now) and was highly significant in banking, finance, manufacturing, and mining-quarrying. The recent growth of the use of the corporate form is particularly noteworthy in the latter two fields. From 1904 to 1929 the ratio of corporately organized to all manufacturing establishments rose from 23.6 to 48.3 per cent; for mining and quarrying, comparable figures for 1902 and 1929 are 28.6 and 63.0 per cent. In terms of the value of products, manufacturing corporations produced 73.7 per cent of the total value of manufactured products in 1904 and 92.1 per cent in 1929. Even greater dominance is noted in mining and quarrying; here corresponding percentages in 1902 and 1929 were 86.3 and 95.7 per cent. Along these same lines, the Berle and Means data indicate that 99 per cent of the wage earners in the copper industry, 98 per cent in iron ore, 97 per cent in lead and zinc, 89 per cent in petroleum and natural gas, and 94.2 per cent (Twentieth Century Fund figure) for all mining and quarrying were employed by corporations in 1919.

But individual enterprise and partnerships still remain significant forms in other fields. Five branches of activity—agriculture and related industries, construction, service (excluding government), finance, and trade—together produced in 1929 approximately one half our national income, the separate percentages being respectively 9.1, 3.7, 10.2, 13.6, and 13.7 per cent. The corresponding figures on the ratio of income produced by corporations in each class to total income produced by all firms in each class are 6, 33, 33, 56, and 63 per cent. Thus, on the basis of these 1929 figures, agriculture remains the stronghold of the individualists; it is probable, however, that this position is weaker now than it was in 1929. Trade, sometimes supposed to be in the same category, showed 63 per cent of its entire income produced by corporations in 1929. Fifty-seven per cent of the national income was produced by corporations in 1929, a figure influenced greatly by manufacturing (which produced 23.3 per cent of the national income of which 92.1 per cent was produced by manufacturing corporations).

LARGE-SCALE ENTERPRISE IN AMERICA

Such are some of the data on the place of the corporation in our economic organization. But in the field of big business ($50,000,000 assets or more or $5,000,000 or more annual net income) the corporation, as would be expected on financial and legal grounds, is almost universal. As for the origins of these huge corporations, the Twentieth Century Fund's study emphasizes growth through combination as against growth through reinvestment or through internal expansion financed by public sale of securities. The Fund's data bring out, rather inconclusively, a modified wave character of the combination movement with the principal booms occurring between 1898 and 1902 and in the 1919–1929 period (with especial emphasis on the latter years of this latter period). It might be noted, however, that Berle and Means stressed securities sales rather than mergers as the principal element in the growth of huge corporations. They found, for example, that between 1922 and 1927 about 20 per cent of the growth of the 200 largest corporations could be attributed to additions through merger, whereas 55 per cent resulted from securities sales and 25 per cent from reinvestment of earnings. In the light of these data and the scanty additional data discussed by the Fund, we must modify the conclusion which the Fund's survey drew—that "the combination movement is responsible for a large proportion of America's industrial giants."

CONCENTRATION OF OPERATING UNITS

There follows a valuable chapter on the concentration of operating units in manufacturing and in trade. In 1929, of the 92.2 per cent (previously given as 92.1 per cent) of total value of manufactured products coming from such firms corporately organized, 53.7 per cent was produced by plural (more than one establishment operated by a central office) units, and 38.5 per cent by single units, though, in terms of the total number of manufacturing establishments, only 12.4 per cent were plural. A similar result is reached if we take the number of wage earners employed as a measure of size and consider size as a measure of concentration. In the manufacturing industries, the peak on this criterion is 1919. Manufacturing plants employing 1001 workers and over covered 15.3 per cent of the total number of workers in this field in 1909, 26.4 per cent in 1919, 19.7 per cent in 1921, 24.1 per cent in 1923, and 24.4 per cent in 1929. The data following these figures show similar concentration indexes by separate industry and are extremely interesting. The authors present, for 1933, figures on 84 of the more concentrated manufacturing industries, a group including more than one half of all wage earners in manufacturing in 1933; for each industry is shown the proportion of wage earners employed by the leading six (sometimes seven or eight) concerns in the industry and also the proportion in the three (sometimes four) largest. This gives us a sort of twofold progressive measure of concentration. For instance, cigarettes (the top case) shows 99.4 per cent of all wage earners in that industry em-

(*Continued on page 776*)

[1] "Big Business. Its Growth and Its Place." Prepared under the auspices of the Corporation Survey Committee, Ralph E. Flanders, chairman, Twentieth Century Fund, Inc. Rufus S. Tucker, general director. The Twentieth Century Fund, Inc., New York, 1937.

[2] "The Modern Corporation and Private Property," by A. A. Berle and G. C. Means, The Macmillan Company, New York, 1934.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

BETTER ELECTRICAL APPARATUS WITH MINIMUM WELDING

By A. P. WOOD

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MORE THAN ten years ago electrical manufacturers started to replace their cast apparatus with fabricated welded structural shapes and rolled plates. In a great many cases the fabricated structure was a copy of the casting, with resultant failure to effect any saving in manufacturing cost. This was a costly mistake. The time taken to assemble the various pieces to be welded together required too much labor; when completely welded, the assembly remained in the position of the gross-weight casting; it was again subject to the same machine operations; and, being steel, it must bear an approximate 25 per cent extra labor charge.

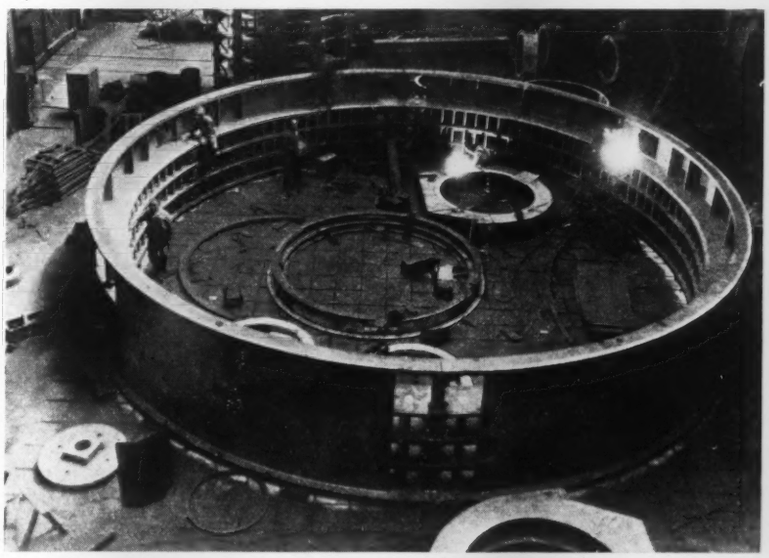

FIG. 1 STATOR FRAME OF A 77,500-KVA 88.2-RPM VERTICAL WATER-WHEEL-DRIVEN GENERATOR

(This frame weighs approximately 126 tons and will have nearly 230,000 laminations assembled into it.)

Having in mind all functions of the cast design the problem is to produce a design, which is not a copy of the earlier one but lacks some of the curves that were so noticeable and easy to obtain when castings were made from expensive patterns. That is, starting without preconceptions, designers must plan on welding as few parts as possible of the plates and structural shapes listed by the various steel mills. In cases where most of a product is still made of castings, it can now be readily changed over to a welded fabricated design simply by studying designs of similar products. Because of steady progress, many of the pitfalls associated with new designs have now been eliminated.

REDUCING SCRAP AND MANUFACTURING COSTS

The present-day designer is not handicapped by being required to make expensive patterns which require a large storage space. He has steel plates and structural shapes which cost less per pound than cast iron or cast steel. This cost advantage at the start should not be dissipated in a design having too many parts to be welded together.

In many cases a stronger, cheaper, and better design, having the old familiar curves, can be obtained by bending one piece of steel in a breaker rather than welding two pieces together. This results in less scrap, and it must never be forgotten that scrap is a part of the cost. An example of reducing scrap is to flame-cut one side of a stator frame from a large square steel plate; what would formerly be scrap is then flash welded together to make the other side. In larger heavy pieces of plate of various shapes a template can be made and sent to the plate mill, thus saving reburning the rectangular shapes on which a cutting charge of so much per pound would otherwise be paid. Since the scrap never leaves the mill, the charge of cutting it into smaller pieces to ship back to the mill is saved.

A modern electrical design, to reduce manufacturing cost, must embody steel plates welded together. Moreover, such a modern tool as welding should be utilized to eliminate boring-mill operations and to reduce the number of setups, jigs, and minor machine operations, thus more than compensating for the extra labor and overhead which are charged for machining steel instead of cast iron.

If welding is used to fabricate steel plate and rolled sections of various thicknesses on rotating parts, good practice is to anneal the completed rotor if the peripheral speed is more than 4000 fpm.

When some cast part of an electric generator has been superseded by one of welded fabrication, the foundry personnel has often requested that it be given an opportunity to reproduce the fabricated design by one of similar cast design, which of course, has less of the sweeping curves of the original cast design. In several cases, the result has been a new cast design that is considerably cheaper than the welded fabricated design. This accounts for a completed piece of apparatus which consists of fabricated and cast parts.

Supporting one-piece rings on rotating fields were originally made by the expensive process of cutting them out of square plates or buying rings expanded from a single piece of nickel steel. To a large extent this has been superseded by edgewise

Contributed by the Machine Shop Practice Division for presentation at the Fall Meeting, Erie, Pa., Oct. 4–6, 1937, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

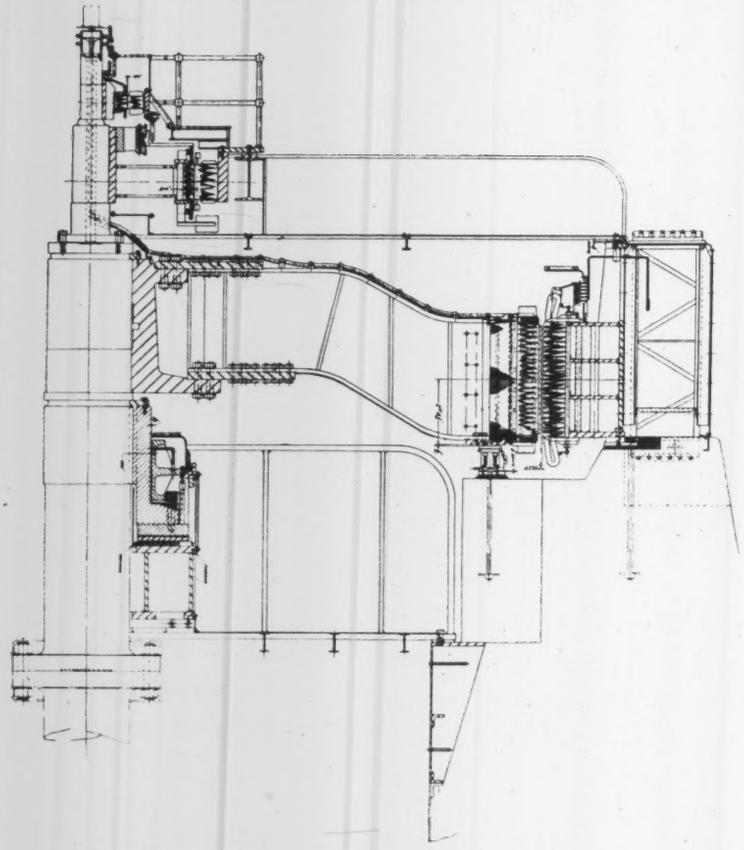

FIG. 2 CROSS SECTION OF A 47,000-KVA VERTICAL WATER-WHEEL-DRIVEN GENERATOR

rolling strips into circles and flash welding the ends together. Tests have shown these welds to be equal to the tensile strength of the metal itself; and by retaining the bead at the weld, where permissible, a much stronger piece is obtained.

Spot welding has been used on air-duct fingers of stator frames for more than 25 years. Arc welding has been used more than 20 years on clamping flanges made of sheared stock strips to retain the stator laminations. Flash welding has saved many plates of various thicknesses from going to the scrap pile. Atomic welding has been used to advantage on many smaller fabricated parts. Automatic welding with bare and covered electrode is fast replacing the personal factor ever present in hand welding and is insuring uniformity throughout the length of the weld, not forgetting the saving in time, money, and welding wire over that of hand welding.

WELDING A 126-TON STATOR FRAME

Fig. 1 shows a large stator frame for a 77,500-kva vertical water-wheel-driven generator, into which will be assembled approximately 230,000 laminations. The high degree of accuracy now achieved in welding has made it possible to make this frame of six sixty-deg removable nonmachined sections and do it more accurately than would be possible if expensive space-taking machine tools had been used to finish the six sections and bore them out after bolting them into a circle. The weight of this welded stator is approximately 126 tons. Years of experience and the use of gages and mandrels make it possible to fabricate, without sacrificing quality, a fine product in the space formerly occupied by large tools which were required to reduce a gross-weight casting to one of finished dimensions.

Designers' confidence in welding is illustrated by Fig. 3, which shows a large bearing bracket consisting of welded fabricated beams, that were too large to buy, mounted on the stator shown in Fig. 1. This bracket has a diameter of more than 40 ft and supports a welded-fabricated oil-filled thrust-bearing housing which in turn supports a load as high as 2,000,000 lb without an oil leak or other structural defect. The housing was tested for leaks before any oil was put in by drilling into the weld and applying air pressure. A simple method of testing welds for leaks is to paint the weld with soapy water. If a bubble appears, the weld is incomplete at that spot.

REDUCTION IN GENERATOR-FRAME HEIGHT EFFECTED BY WELDING

Fig. 2 shows a cross section of a 47,000-kva vertical generator with large fabricated bearing bracket at the bottom and a drooping welded-fabricated rotating-field spider, one of the first of its kind ever manufactured. This spider, which is shown in Fig. 4, illustrates more clearly how it is possible to reduce the height of the stator frame. The laminated rim is assembled on the radial removable arms and consists of $\frac{1}{8}$- and $\frac{1}{4}$-in. die-punched plates to which the poles are keyed. This rim is of the full-floating type, which means that when it expands because of centrifugal forces, the only strain on the fabricated rotating spider is due to the torque transmitted to the rim.

Where hydrogen is used instead of air in rotating-field condensers up to 60,000 kva, it is not necessary to have the cylindrical sections of the stator in contact with the retaining straps for holding together the sections welded outside the cylinders; for welding has so far advanced that even hydrogen can be confined in direct contact with the welds without a leak. Fig. 5 shows a 60,000-kva condenser of this design.

As time goes on, better designs are completed with fewer parts and minimum welding.

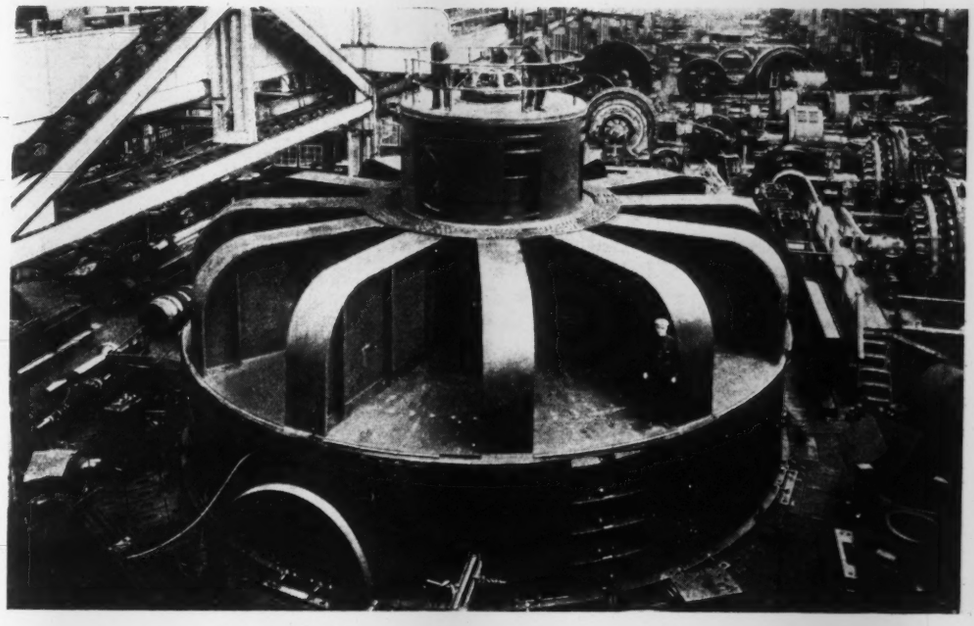

FIG. 3 STATOR FRAME, SHOWN IN FIG. 1, WITH UPPER BEARING BRACKET MOUNTED IN PLACE

(This bracket, which consists of welded beams that were too large to be purchased, is over 40 ft in diameter and supports a welded housing for an oil-filled thrust bearing which supports a load of 2,000,000 lb.)

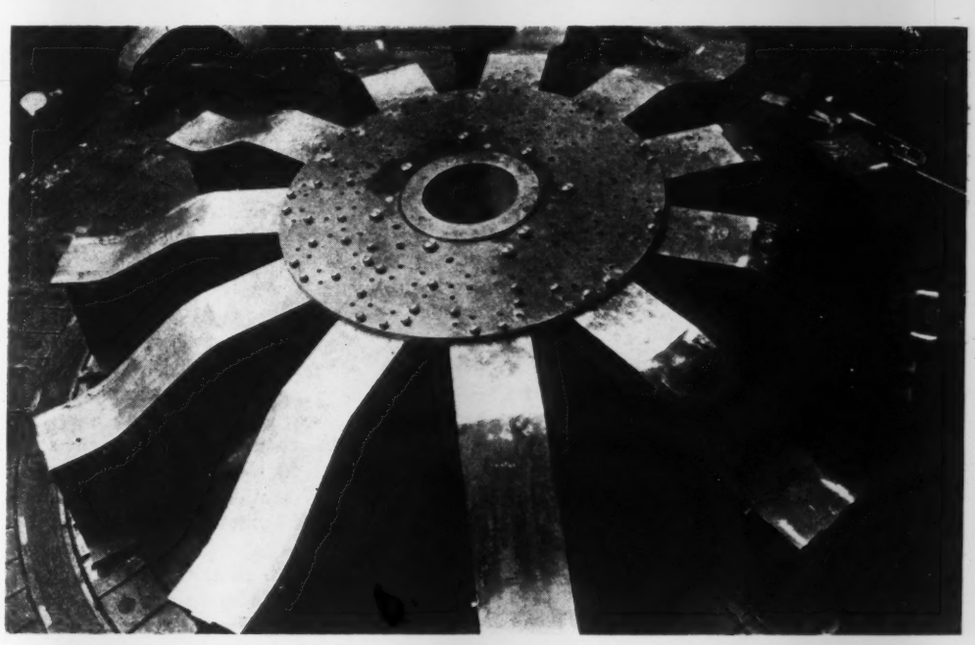

FIG. 4 DROOPING WELDED ROTOR FOR THE 47,000-KVA VERTICAL GENERATOR SHOWN IN FIG. 3

(This rotating-field spider is one of the first of its kind to be made. The design effects a reduction in the height of the stator frame, and in operation, the spider rim is only subjected to the strain produced by the torque transmitted to it.)

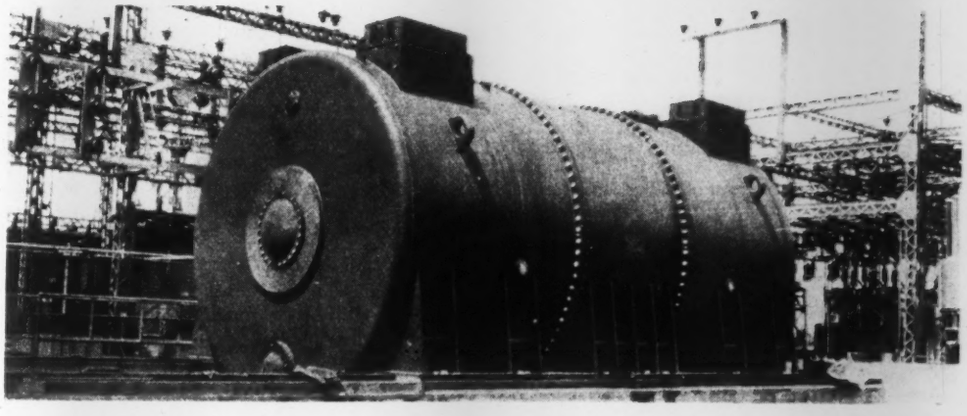

FIG. 5 COMPLETELY ASSEMBLED 60,000-KVA 600-RPM HYDROGEN-COOLED SYNCHRONOUS CONVERTER

EARNINGS *of* ENGINEERS

Fifth Series of Results of the Survey of the Engineering Profession Conducted by the U. S. Bureau of Labor Statistics

FOUR SUMMARY reports based on analyses made by the United States Bureau of Labor Statistics on returns from 52,589 engineers have already appeared.[1] The present article deals with income and earnings in the engineering profession from 1929 to 1934 with which the fifth report[2] deals. From the introductory paragraphs of this report, in which the results are summarized, the following paragraphs are quoted, together with the concluding paragraphs of the report.

Reports from 52,589 professional engineers to the Bureau of Labor Statistics, in its survey of the engineering profession, undertaken at the request of the American Engineering Council, make it possible to relate the income data to many aspects of professional engineering activity. These income data are probably the most comprehensive ever presented in regard to a professional group. The following general findings appear from analysis of the reports.

In 1929, 50 per cent of the 30,032 reporting engineers earned more than $3412, and 50 per cent earned less than that amount. Twenty-five per cent earned more than $5012, but only 10 per cent had incomes in excess of $7466 per annum. On the other hand, 25 and 10 per cent of the engineers earned, respectively, less than $2509 and $1878 per year.

Comparison of the incomes for 1932 and 1934 with those reported for 1929 shows that from 1929 to 1934, the sharpest absolute declines occurred in the two higher income groups. Their percentage decreases were least, however, averaging 31.2 and 31.6 per cent, whereas the middle values of income declined by 33 per cent, and the two lower levels by 41.3 and 53.6 per cent, respectively.

Almost two thirds of these decreases in earned annual income occurred between 1929 and 1932. There were further decreases from 1932 to 1934.

Among the several professional classes, the divergences in earning capacities were most marked in the higher levels of income. Furthermore, the ranking of the profession on the basis of earnings opportunity was the same in the highest 10 and 25 per cent only.

In 1929, without regard to the age distributions of the different classes, 10 per cent of the mining and metallurgical engineers earned more than $9912 per year; chemical and ceramic engineers ranked second with 10 per cent earning more than $9103, and were followed in order by mechanical and industrial engineers ($8508), electrical engineers ($7185), and civil engineers ($6507). At the upper 25 per cent level, mining and metallurgical engineers reported earnings of $6301 per year, and those of the other professional classes ranged from 4 per cent lower for chemical and ceramic engineers to 28 per cent lower for civil engineers. This order of professional classes was also maintained in 1932 and 1934.

In 1929, the earnings of the mining and metallurgical engineers were highest in the middle and two lower levels of income, while those of the electrical engineers were lowest. At these three levels, the earnings of the former were $4010, $2839, and $1985; for the latter they were $3277, $2339, and $1662. Over these three levels, the relative positions of the three remaining professional classes changed. There were further shifts in 1932 and 1934.

The data also show that, over the period 1929 to 1934, relatively the smallest shrinkages in earnings were reported by the civil engineers, while the chemical and ceramic engineers suffered the greatest cuts. Over the five income levels, the former ranged from 29.0 to 47.2 per cent, the latter from 35.6 to 63.8 per cent.

Analysis of the income data reported by all engineers in 1929, 1932, and 1934 shows that earnings advanced with age in three distinct phases, showing initial periods of exceptionally rapid rise, followed by two others of slower rates of increase. The age spans of these phases varied with the income level.

With advancing age, the spread in earnings became most accentuated beyond the age of 38. Thus, at the ages of 44 and 60, the incomes of the upper 25 per cent differed from the median or middle value by 41.0 and 51.0 per cent. The corresponding incomes of the upper 10 per cent at these ages were greater than the median by 116.0 and 157.0 per cent. Even in 1932 and 1934, this advantage in earning capacity was maintained.

The earnings of the engineers in the lower income levels ceased to increase at a relatively early age. These showed a level period before beginning to decline, whereas the higher levels of income showed continuous increases for a considerably longer period, after which, however, they declined at a much greater rate.

Over the period 1929 to 1934, a rise in earnings occurred for the youngest engineers who were in the profession in 1929 and who were 30 years of age or less in 1934. Thereafter there were progressively larger declines for the older engineers.

Comparison of the earnings of engineers of identical ages in 1929 and 1934 shows that the average income of engineers who had been out of college for two years declined 43 per cent. The income of those who had been out five years declined 35 per cent. For older engineers the decline approximated 30 per cent.

Consideration of the incomes reported by engineers of different educational backgrounds shows that those with a formal engineering education did receive a higher income. The differ-

(*Continued on page 714*)

[1] "Education of the Engineer," MECHANICAL ENGINEERING, August, 1936, pp. 505–509. Also: "Educational Qualifications in the Engineering Profession," *Monthly Labor Review*, June, 1936, pp. 1528–1542; also reprinted as Bureau of Labor Statistics Serial No. R. 400.

"Unemployment of the Engineer," MECHANICAL ENGINEERING, March, 1937, pp. 178–181. "Unemployment in the Engineering Profession," prepared by A. F. Hinrichs, chief economist, and A. Fraser, Jr., Division of Wages, Hours, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, January, 1937, pp. 37–59; also reprinted as B.L.S. Serial No. R.497.

"Employment of the Engineer," MECHANICAL ENGINEERING, May, 1937, p. 350. "Employment in the Engineering Profession, 1929–1934," prepared by Andrew Fraser, Jr., Division of Wages, Hours, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, April, 1937.

"Security in Engineering Employment," MECHANICAL ENGINEERING, August, 1937, pp. 609–610. Also: "Security of Employment in the Engineering Profession," prepared by Andrew Fraser, Jr., Division of Wages, Hours, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, May, 1937.

[2] "Income and Earnings in the Engineering Profession, 1929–1934," prepared by Andrew Fraser, Jr., Division of Hours, Wages, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, August, 1937.

RESIDENCE *and* SMALL-OFFICE AIR CONDITIONING

By G. B. HELMRICH

THE DETROIT EDISON COMPANY

THE Detroit Edison Company has sponsored research and experimental work in residential and small commercial-office comfort cooling and air conditioning for the last six years, and the author has had an active part in this work ever since its inception. Although its primary purpose was promoting use of air-conditioning equipment for its electrical load-building possibilities, the problem was approached from a research viewpoint as well, and every effort was made to develop cooling methods that were scientifically sound as well as commercially feasible. Results of these cooling experiments have been correlated from year to year with similar work carried on in the same period at the University of Illinois research residence, under the direction of Prof. A. P. Kratz, and with the various research activities of The American Society of Heating and Ventilating Engineers[1] in the field of summer cooling. Experience gained in the summer-cooling experimental work sponsored by The Detroit Edison Company and its correlation with similar work of the aforementioned organizations serve largely as the basis for this paper.

COMFORT COOLING

Although air conditioning, from the engineer's viewpoint, involves simultaneous and independent control of temperature, relative humidity, and air motion, summer-comfort conditions can be appreciably improved by such a well-known device as the furnace fan or the more recently developed attic-ventilating fan. Both the furnace and attic-ventilating fans depend for cooling effectiveness upon their ability to circulate relatively large volumes of outdoor air at a time when the temperature is lower outdoors than that indoors. Cooling by such means has been popularly termed "comfort cooling" and no discussion of residential cooling would be complete without at least a brief reference to these simple first steps. Several experimental installations of attic-ventilating fans and tests of furnace fans were made in the last five summers, beginning in 1932.

Tests of the cooling power of the furnace[2] fan were made in the same residence[3] in which artificial-cooling experiments, described later in this paper, were made. These tests indicate that a furnace fan of the size usually installed, one capable of circulating four to six air changes per hour, cannot bring enough outdoor air into a residence to affect the indoor temperature appreciably, either at night or the following day. Similar tests conducted at the University of Illinois research residence show that the furnace fan must have a minimum capacity of about nine air changes per hour, if night air cooling is to be effective, and even this high rate of air change is not as effective as opening a majority of the windows and depending upon natural ventilation.

Tests were also made of the cooling effect produced by simply recirculating air in the daytime. As recirculation of air can only produce cooling by the effect of air motion, determination of this cooling value is essentially a matter of measuring the air velocity accurately and then determining, by use of the comfort chart, the effective temperature corresponding to this velocity. Tests were made in the living room of the Detroit residence, where the rate of air change was 7.4 per hour and the air velocities were measured with a Kata thermometer, the most practical instrument for field use in measuring low air velocities. The highest velocity measured at the 38-in. level was 42 fpm, and, with a room temperature of 78 F, this corresponded to an effective temperature of 72 deg. As the corresponding effective temperature for still air is 73 deg, this indicates that the air movement induced by furnace-fan recirculation had reduced the effective temperature 1 deg, which is equivalent to about a 2-deg drop in dry-bulb temperature. This is hardly enough drop in temperature to justify any claims for this method of cooling, and probably the rate of air change would have to be 15 per hour to accomplish effective cooling.

The second step in improvement of summer comfort may well be the installa-

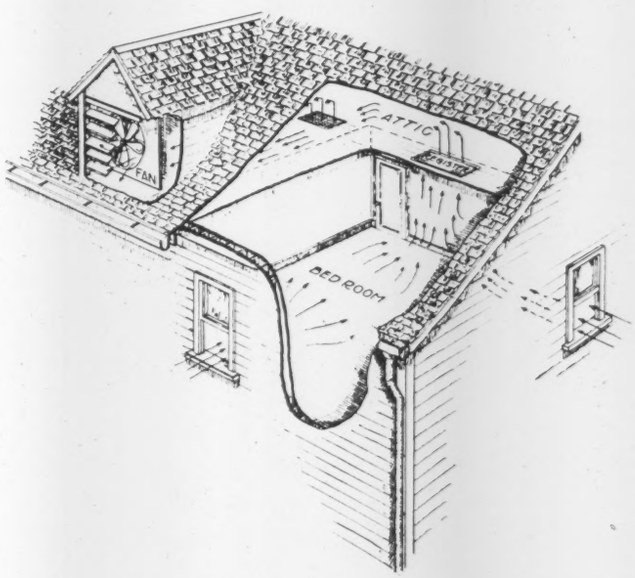

FIG. 1 TYPICAL INSTALLATION OF AN ATTIC-VENTILATING FAN

Contributed by the Process Industries Division for presentation at the Fall Meeting, Erie, Pa., Oct. 4–6, 1937, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[1] "Study of Summer Cooling in the Research Residence for the Summer of 1933," by A. P. Kratz and Seichi Konzo, *Heating, Piping, and Air Conditioning*, December, 1933, pp. 613–625; also: "Study of Summer Cooling in the Research Residence for the Summer of 1934," by A. P. Kratz, Seichi Konzo, M. K. Fahnestock, and E. L. Broderick, *Heating, Piping, and Air Conditioning*, January, 1935, pp. 29–40.

[2] "Cooling Power of the Furnace Fan," by G. B. Helmrich, *Heating & Ventilating*, March, 1937, pp. 52–54.

[3] Referred to throughout this paper as the Detroit residence.

tion of an attic-ventilating fan. This type of fan, as the name indicates, is installed in the attic of a residence or a small commercial-office building and draws large volumes of cooler night air through open windows into the rooms to be cooled and thence through ceiling grilles or an attic stairway to the fan, where it is discharged back to the outdoors through attic windows or louvers. Installation will vary with the local conditions in each case, but the path of the air through the rooms to be cooled and to the fan should be as direct as is practicable, if the full fan capacity is to be utilized. Fig. 1 shows a typical installation of such a fan.

Tests conducted on several attic-fan installations in the Detroit area, as well as similar tests made on an installation in the University of Illinois research residence, show that best results are obtained when the fan circulates about 30 to 35 changes of air per hour, and for an ordinary three-bedroom, two-story house, this can be accomplished by a fan with a

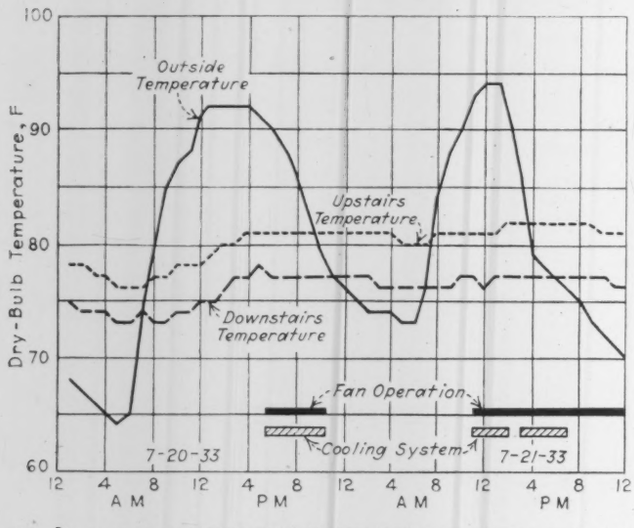

FIG. 2 EFFECT OF ATTIC-FAN VENTILATION UPON THE TEMPERATURE OF AN UPSTAIRS ROOM

capacity of 3000 cfm. The gain from circulating more than 35 air changes per hour is small, but circulating less than 10 air changes per hour is not effective.

An example of the effectiveness of night-air cooling by an attic fan is shown in the temperature curves of Fig. 2. These curves are typical of an installation circulating about 36 air changes per hour through the upstairs rooms, and the inside temperature will be seen to follow the declining outdoor temperature closely. Best results are obtained by operating such fans all night, as the heat stored up in the walls and ceilings soon raises the room temperatures back to uncomfortable values if the fan is shut down before midnight.

One serious disadvantage of the attic fan is that bringing such large volumes of air into a residence carries with it the risk of also introducing considerable dust in certain localities, which may result in serious discomfort to people suffering from allergic diseases caused by air-borne pollens. In this respect the furnace fan is superior, as it usually draws its air supply through a filter. Attic-fan installations of the type and capacities just described can be made for a cost of about $125, and the operating cost for a normal summer in the Detroit area will not exceed $5.

AIR CONDITIONING FOR SUMMER COMFORT

The first fundamental requirement in the summer air conditioning or cooling of a structure is that the structure itself be well-constructed and well-insulated and that steps be taken to shade the windows against sun effect. A residence insulated with rock wool or its equivalent, both in the ceilings and side walls, may be considered a well-insulated structure. A study of cooling tests made in the University of Illinois research residence, which is not insulated, and a comparison of these results with those obtained in similar tests conducted by the author on a cooling plant installed in a well-insulated Detroit residence, indicates that insulation can be credited with about a 30 per cent reduction in cooling load. These same tests also show that awnings or blinds at the windows reduce the calculated cooling load by 25 per cent and the actual operating cost of the cooling system by 20 to 30 per cent. Both the investment and operating costs for cooling a poorly constructed and uninsulated residence are much higher than can usually be warranted by the benefits obtained.

The second basic requirement is that means be provided for both distributing the cooled air to the rooms and returning the warm air to the cooling unit. This is a more important consideration, in many instances, than the design and installation of the cooling unit itself, as it frequently proves difficult to install air ducts in an existing structure heated by radiators. In cases where installing duct work for air distribution is difficult, and especially in small commercial offices, installing space-cooling units is most economical, and the newly developed self-contained air-cooled unit is well suited to this type of cooling, as these units require no water or drain connections.

Structures heated by mechanical warm-air heating systems present an easy problem in air distribution as the existing duct work and registers, including those of the older baseboard type, have proved satisfactory for distributing cooled air. Many of the newer homes are being equipped with indirect warm-air or combination steam-radiator and indirect warm-air heating systems, with high side-wall registers in many instances, and installing a cooling coil in the same housing with the heating coil is comparatively simple. The existing distribution system will usually be found to be well adapted to cooling, especially if high side-wall registers are used.

While, for design purposes, certain indoor and outdoor temperatures and relative humidities must be assumed as a basis for calculating cooling loads, the fact should be borne in mind that people can be comfortable in summer over wide ranges in temperature. For the Detroit area, an assumption of an outdoor temperature of 93 F and 50 per cent relative humidity and an indoor temperature of 80 F and 45 per cent relative humidity or 73 deg effective temperature is satisfactory. We have found in our Detroit experience that maintaining an indoor effective temperature of 72 to 73 deg, corresponding to 77 to 79 F and 50 to 60 per cent relative humidity, gives satisfactory results. When extreme outdoor temperatures occur, say 100 F or higher, the indoor temperature should be permitted to rise to 80 F or slightly above, with an effective temperature of about 74 deg. By "effective" temperature is meant an empirically determined index of the degree of warmth perceived on exposure to different combinations of temperature, humidity, and air movement.[4] It is neither necessary nor advisable to install sufficient cooling capacity or expensive control equipment to maintain optimum conditions at all times. Some designers even advocate considerably higher indoor temperatures than those mentioned, on the presumption that "cold shock" or a feeling of discomfort will be experienced by a person entering the cooled atmosphere, but our experience indicates that this is not generally true of resi-

[4] "The American Society of Heating and Ventilating Engineers Guide," American Society of Heating and Ventilating Engineers, New York, N. Y.

dences but may well be a matter for concern in commercial offices. In fact we have found that 74 deg effective temperature is a little too high for comfort, except for extreme outdoor temperatures.

CALCULATING COOLING LOAD

The fourth fundamental requirement for an economical design of a cooling system is that the cooling load be calculated so that allowances for extreme conditions are not made cumulative to the extent of grossly overestimating actual cooling requirements. Because of heat capacity of the walls and ceilings, we have found that the calculated maximum cooling load is usually about one third higher than the actual, unless the factor of time lag in heat transfer, caused by heating of the building structure, is taken into account. Tests at the University of Illinois research residence showed that the maximum load on the cooling coils was 30,000 Btu per hr, while the calculated load was 40,000, and this maximum load persisted for about four hours after calculations showed that the load should be below this figure.

Calculated figures would be correct if transmission of heat were instantaneous, but, allowing for lag in heat transfer, while the total amount of cooling in British thermal units removed corresponds approximately with the calculations, actual maximum load required under the assumed conditions was about 25 per cent less. This simply means that the cooling equipment operated at a lower maximum capacity than calculated but over a much longer period so that the net cooling result was the same. An important point to be realized, therefore, is that some correction must be applied to the maximum cooling load, as normally computed, to avoid installing equipment possibly one third larger than necessary.

Table 1 shows a suggested method of correcting the calculated cooling load for the heat capacity of the structure. Essentially, this method consists in deducting the calculated cooling load, due to occupancy and infiltration, from the total actual cooling load and assuming that the difference is the test-transmission load and that the ratio between test-transmission and calculated heat-transmission loads is a measure of the proportion of heat received by the outside walls and ceilings which is actually transmitted into the rooms in the particular period for which the load is calculated. This correction factor would have to be determined for the different types of wall construction and the various kinds of structure. Both our experience with the Detroit residence and tests at the University of Illinois research residence indicate that the actual heat-transmission load for a residence of good frame construction will be reduced sufficiently by heat capacity of the structure to make an actual maximum cooling load about 25 to 30 per cent less than the calculated maximum load.

CHOOSING COOLING METHODS

Artificial cooling of a residence can be accomplished by any one of four principal methods, well water, ice, refrigerating machine, or a combination of dehumidifying and cooling equipment. Well-water cooling is, of course, limited to those localities where it is available but is a fairly satisfactory means of cooling if the water temperature is around 55 to 60 F. Water of higher temperature is not satisfactory for cooling. Drilling a well for cooling purposes involves, however, many uncertainties as to quality and quantity of water obtained, and frequently is not nearly as satisfactory as anticipated.

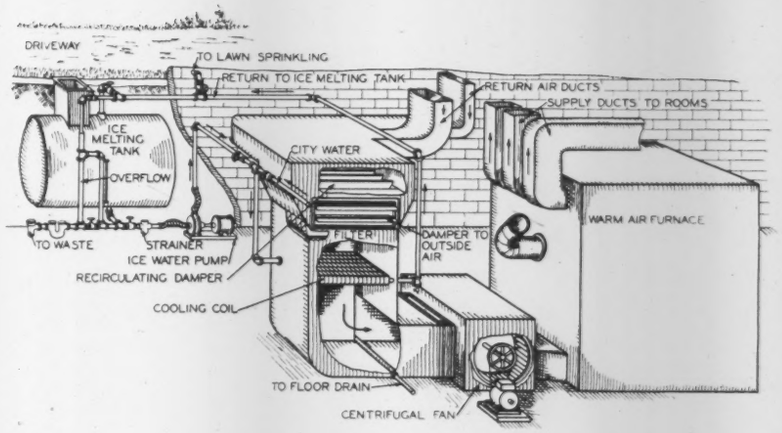

FIG. 3 ICE COOLING SYSTEM FOR THE DETROIT RESIDENCE

If the structure is to be cooled artificially, by either ice or a refrigerating machine, and a central cooling system is to be employed, choice of cooling method lies between an air washer and extended-surface finned-tube cooling coils. The latter is simpler and is better adapted for use in smaller installations than the air washer—especially so since refrigerants are now available which can be safely expanded and evaporated in coils placed in the main air stream. Aside from the distribution system, a mechanical cooling system can be very simple and essentially need only consist of the refrigerating machine, direct-expansion cooling coils, and circulating fan. Essential parts of a central ice cooling system are the ice-melting tank, ice-water pump, cooling coil, and fan.

In the summer of 1932, The Detroit Edison Company installed an ice cooling system in a Detroit residence and experimental data were gathered on the design and operation of this system for two summers. This residence is of moderate size, with four rooms each on the first and second floors, and both ceilings and side walls are insulated with quilt-type insulation, balsam wool and Cabot's Quilt. All windows exposed to the sun's rays were shaded with either awnings or blinds. The total space cooled was 17,200 cu ft.

Ice was chosen as the cooling medium because at that time an ice-cooling system was believed to be most appropriate for

TABLE 1 ESTIMATING ACTUAL MAXIMUM COOLING-LOAD CORRECTION FOR HEAT CAPACITY OF DETROIT-RESIDENCE

	Calculated maximum cooling load	
	1932	A.S.H.V.E. 1936 guide
Number of rooms cooled	8	8
Volume cooled, cu ft	17,200	17,200
Design temperature, F		
Outdoor	93	92
Indoor	80	78
Relative indoor humidity, per cent	50	50
Heat-transmission load, excluding occupancy and infiltration, Btu per hr	24,320	25,133
Occupancy and infiltration load, Btu per hr	11,007	6,500
Total maximum cooling load, Btu per hr	35,327	31,633

Maximum net load on cooling coils, by test = 22,150 Btu per hr
22,150 less 6,500, load due to occupancy and infiltration = 15,650 Btu per hr test transmission load
Ratio between test and calculated transmission loads = 15,650/25,133 = 62.5 per cent
Ratio between actual and calculated maximum loads = 22,150/31,633 = 70 per cent

this kind of service, as it is simple and inexpensive to install. Although we realized that the operating cost, using ice, would be higher than that for mechanical refrigeration, the short duration of the cooling season made this disadvantage seem less serious than it later proved to be. As revenue derived from the sale of electricity to manufacture the ice required for cooling is about the same as that derived from operation of a motor-driven compressor accomplishing equivalent cooling, the matter of revenue to the utility did not influence choice of cooling medium.

ICE COOLING SYSTEM

A diagram of the cooling installation in the Detroit residence is shown in Fig. 3. As the house was heated by a mechanical warm-air system of modern design, it was only necessary to modify existing construction of the return-air chamber to adapt it for installation of cooling coils. The duct system and baseboard registers, as installed for heating purposes, proved to be satisfactory for distributing cooled air.

From the standpoint of temperatures maintained, cooling was satisfactorily accomplished with ice, and Fig. 4 shows typical temperature curves for the system when the ice charge was about 700 lb. Operating costs, however, were out of proportion to benefits derived and proved to be about three times as high, per hour of artificial cooling, as the costs for mechanical cooling, as shown in the summary of operating and cost data, Table 2. An additional disadvantage was the considerable nuisance attached to the use of ice which was ordered by telephone each day, and on some days when ice was ordered at noontime, in expectation of a hot afternoon, changes in the weather made cooling either unnecessary or only required for a brief period. As little ice could be conserved for the next day's use, a considerable quantity was wasted. This experience made the householder so waste conscious that he did not use the system as freely as he wished.

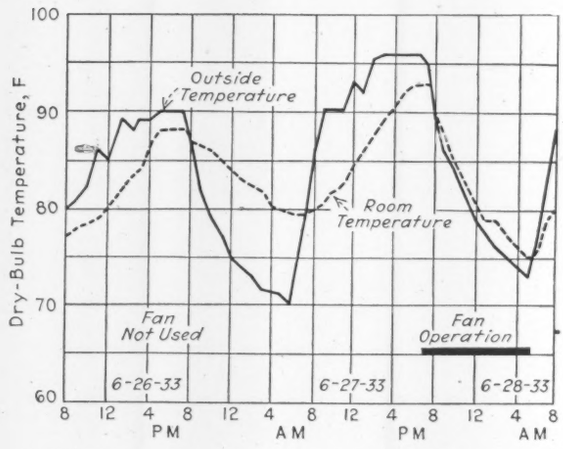

FIG. 4 TYPICAL TEMPERATURE CURVES FOR ICE COOLING SYSTEM

In spite of this unfavorable experience with ice for residential cooling and a similar experience in two of our commercial offices, we realize that ice has a proper place in the field of cooling. Ice systems can be installed advantageously to cool structures having high peak cooling loads but low load factors. In other words, comparatively short or infrequent periods when cooling is required serve to minimize the importance of higher operating costs of ice cooling and tend to make total operating and fixed changes or annual costs compare favorably with the total costs required for mechanical cooling.

TABLE 2 SUMMER COOLING IN A DETROIT RESIDENCE

(Summary of operating and cost data for summers of 1932, 1933, 1934, 1935, and 1936)

Year	1932	1933	1934	1935	1936
Cooling medium	Ice	Ice	2-Ton refrigerating machine[a]	2-Ton refrigerating machine[a]	2-Ton refrigeratin machine[a]
Total degree-hours above 85 F during summer	529	1,408	1,345	540	1,847
Days of artificial cooling	22	22	23[b]	14	18
Hours of artificial cooling	135	134	214	138	245
Hours of fan use only					
Outdoor air cooling	57	120	6	57	11
Recirculation	...	...	114	23	115
Total hours of fan use	192	254	334	218	371
Average cooling-hours per day	6.1	6.1	9.3	9.9	13.6
Electrical energy used					
Ice-water pump and fan, kwhr	94	142	...	...	...
Compressor, kwhr	...	...	437[c]	285[d]	492
Fan, kwhr	...	...	172	114	181
Total energy per year, kwhr	94	142	609[b]	399	673
Condensing water for compressor					
Average, gpm	...	...	2.07	1.4 and 2.1	
Total for season, gal	...	...	26,700	14,790	30,200
Cost of cooling for season					
Ice at $5 per ton	$45.60	$30.60	...	...	...
Electricity at 2 1/4c per kwhr	2.12	3.20	$13.71	$9.00	$15.15
Condensing water at 20c per 1000 gal	...	...	5.34	2.96	6.04
Total operating cost	47.72	33.80	19.05[b]	11.96	21.19
Average daily cost of artificial cooling	2.16	1.54	0.83	0.85	1.17
Average hourly cost of artificial cooling	0.35	0.25	0.089	0.087	0.086

[a] Refrigerating-machine data: Refrigerant used, Freon; condensing unit had a two-cylinder compressor that was driven by a 2-hp, 220-volt, single-phase, repulsion induction motor; compressor speed was 400 rpm in 1934; in 1935, machine was operated at 1 1/2 tons' capacity or 290 rpm for 63 hr in early portion of season and at 2 1/3 tons' capacity or 500 rpm for remaining 75 hr; direct-expansion cooling coil had a coil bank measuring 29 × 25 × 9 1/4 in. deep or a face area of 4.41 sq ft; face velocity of air through coils when handling 1570 cfm was 356 fpm; actual static-pressure drops were 0.11 in. of water through coils and 0.265 in. of water for entire duct system; operating coil pressure varied from 36 to 45 lb per sq in.; and operating coil temperature varied from 39 to 48 F.

[b] Corrected for five cooling days in June when machine was not available.

[c] Power required by compressor at full load was 2.04 kw.

[d] Power required by compressor at full load was 1.56 kw for 63 hr and 2.64 for 75 hr (average for test days only).

MECHANICAL COOLING

In the summer of 1934, the ice system in the Detroit residence was replaced by a 2-ton refrigerating machine and a diagram of the system, as actually installed, is presented in Fig. 5. If the size of refrigerating machine required for this installation had been determined by usual methods for computing cooling loads, a 3 or 4 ton machine would have been chosen, but we knew from our experience with the ice cooling system that a capacity of 2 tons, or 24,000 Btu per hr of refrigerating effect, would maintain satisfactory indoor conditions in this particular residence. The machine was operated for a total of 214 hr which were spread over 23 days dur-

ing the first season. A schedule for operating the machine which gave very satisfactory results was soon developed by the householder. On warm days the compressor was started at about 8 a.m., and operated from 10 to 13 hr, or until 9 p.m. This permitted the occupants to get a "jump" on the cooling load, so to speak, and enabled them to hold the indoor temperature down to about 78 F downstairs and around 80 F upstairs. This would not have been possible had machine operation been delayed until midafternoon, especially on the hottest days. Indoor relative humidities of 60 to 70 per cent when cooling started were reduced to between 60 and 63 per cent after two to three hours of cooling and to about 50 or 55 per cent at the end of the cooling periods.

Two of the most severe tests of the cooling system occurred, one in July, 1934, and the other in 1936. In the July 24, 1934, test, the machine was started at 4 p.m., when the outdoor temperature was 100 F, and operated continuously until 10 p.m. on the following day, a period of 30 hr. Table 3 gives test data for this day and also for a test made on July 13. Outdoor temperature exceeded 97 F on the second day and no windows were opened during this cooling period. On that day, the upstairs temperature varied between 73 F at 6 a.m. and 79 F at 8 p.m., while the downstairs temperature did not exceed 78 F. No outdoor air was drawn into the system during this period, but the occupants reported that the condition of the air in the sleeping rooms was satisfactory. Reduction of relative humidity to a minimum of 52 per cent at the end of the cooling period was undoubtedly a large factor in producing this condition. During the period in 1936 when we had seven consecutive days when the outdoor temperature reached or exceeded 100 F, the machine was operated continuously and downstairs temperature was around 78 to 80 F and upstairs about 79 to 83 F. The downstairs temperature only exceeded 80 F on one occasion, when it reached 80½ F at 9 p.m. on a day near the end of the hot spell, and the upstairs reached the maximum of 83 deg on one occasion. Outdoor air was not brought into the system during this period.

As the fan was connected into the electrical circuit so as to operate after the refrigerating machine was shut down, it was customarily permitted to run until the occupants retired at night, when it was then shut off by manual control. Recirculation and outdoor-air dampers were interconnected so that closing of the former automatically opened the latter to receive air from out of doors through the basement. Night-air cooling was used considerably in 1935 but only slightly in 1936.

Reduction in hours of night-air cooling was due primarily to the fact that both tests of the system and experience of the occupants indicated that operation of the furnace fan, circulating about six air changes per hour for approximately a twelve-hour period in the night, had no measurable effect on the need for artificial cooling during the following day. Natural ventilation through open bedroom windows was more effective for cooling than the fan. A furnace fan must have sufficient capacity to circulate about nine air changes per hour if the cost of artificial cooling is to be reduced appreciably.

Operation of the refrigerating machine in the Detroit residence is controlled by a low-voltage thermostat which is wired to control a solenoid valve that is placed in the liquid line supplying refrigerant to the cooling coils. When the thermostat calls for cooling, the liquid valve opens and allows refrigerant to flow into the cooling coil. After vapor pressure in the coil has built up to about 40 lb, the low-pressure control closes the starting contactor and starts the refrigerating machine, thus automatically starting the circulating fan. When the room temperature has been reduced to that of the thermostat setting, the liquid valve is closed, and the machine

TABLE 3 AIR TEMPERATURES AND RELATIVE HUMIDITIES FOUND IN TESTS OF COOLING SYSTEM

	July 13, 1934			July 24, 1934		July 25, 1934
	3:15 p.m.[a]	4 p.m.	5:15 p.m.	3:50 p.m.[b]	6 p.m.	10 p.m.
Outdoor						
Wet bulb, F.	...	74.5	...	...	...	...
Dry bulb, F.	87.0	90.0	...	100.0	100.0	...
Relative humidity, per cent.	...	48.0	...	26.0	...	...
Indoor						
Living room, F	78.0	...	...	78.5	79.0	77.5
Dining room, F	80.0	...	77.0	...	81.0	...
Kitchen register, F.	66.5	...	65.5	...	...	...
Dining - room register, F.	67.0	...	66.5	...	...	...
Upstairs bedroom, F.	...	...	...	...	80.0	...
Relative humidity, per cent.	62.5	...	53.0	59.0	...	52.0
Cooling coil						
Entering air, F.	74.0	74.0	74.0	...	75.5	...
Leaving air, F.	65.0	64.5	64.0	...	65.5	...
Cooling load						
Latent-heat load, Btu per hr.		4,100			5,350	
Sensible-heat load, Btu per hr.		16,900			16,800	
Total cooling load, Btu per hr.		21,000			22,150	
Condensing water						
Entering condenser, F.		62			...	
Leaving condenser, F.		83			...	
Flow through condenser, gpm		2.17			...	
Heat rejected to cooling water, Btu per hr.		22,800			...	

[a] Cooling started at 2:45 p.m.

[b] Cooling started at 3:50 p.m. on July 24 and continued until 10 p.m. July 25, a run of over 30 hr.

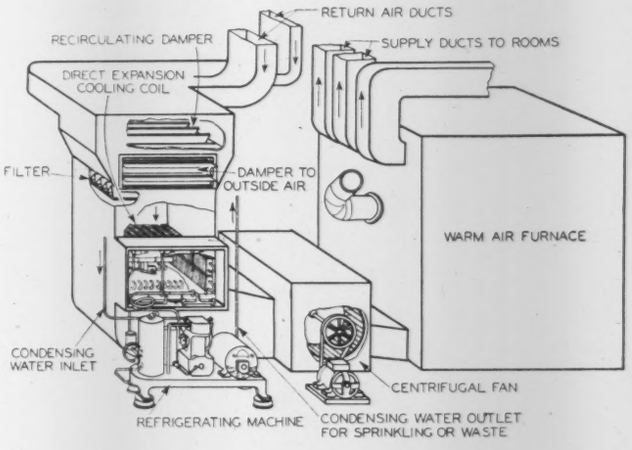

FIG. 5 MECHANICAL COOLING SYSTEM FOR THE DETROIT RESIDENCE

"pumps down" until the suction pressure is reduced to about 7 lb, at which pressure the low-pressure control stops it, but the fan continues to circulate air until stopped by a conveniently located manual control.

In actual practice, this system of controls proved to be considerably more complicated than was really necessary, as the capacity of the cooling coil and refrigerating machine was well balanced against the cooling load and little or no tendency to overcool existed, and, therefore, few occasions arose when the

thermostat was needed. Except in cases where the refrigerating capacity installed is considerably in excess of cooling requirements, cooling-system control need only consist of a set of push buttons for starting and stopping compressor and fan.

OPERATING COSTS AND ELECTRICAL-ENERGY CONSUMPTION

Table 2 summarizes operating and cost data for the last five summers for the cooling system installed in the Detroit residence. Total operating costs vary between $12 for a mild summer and $21 for a warm one.

In seeking to find a measuring unit proportional to energy consumption and operating hours of air-conditioning equipment, examination of our data on the Detroit residence showed that cooling was usually required when the outdoor temperature exceeded 85 F, and we found that the number of degree-hours in a summer which exceeded that figure was a fair measure of the cooling hours required during that summer as compared to others. Table 2 indicates reasonably good correlation between cooling hours per season and degree-hours above 85 F for the same summer. This correlation will not hold good, of course, in cases where a large portion of the cooling load comes

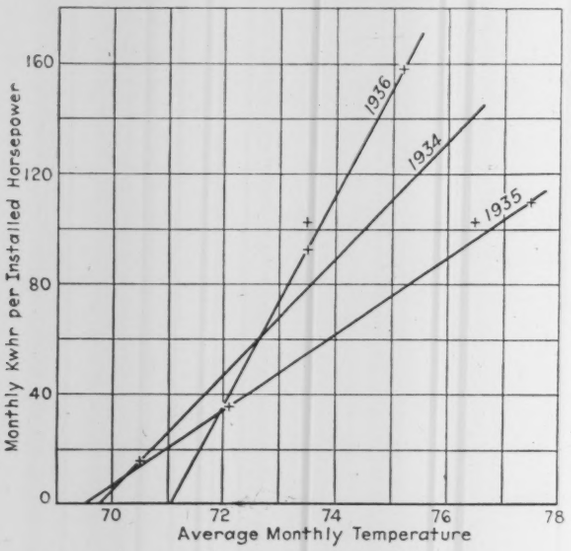

FIG. 6 DEGREE-DAY BASE TEMPERATURE FOR COOLING

from internal sources, but considerable evidence is available to indicate that it is reasonably applicable to residences.

A recent article[5] by A. D. Marston, of the Kansas City Power & Light Co., suggests that a base temperature might be determined for various classes of air-conditioning installations so that the number of degree-days above this base temperature would be proportional to hours of operation or energy consumption of the equipment in the same way that the degree-day is proportional to fuel consumption in a heating plant. Fig. 6 shows the kilowatt-hours per installed horsepower, for the Detroit residence, plotted against average monthly temperatures. These curves indicate that possibly 70 F might be used as the base temperature for figuring the degree-days in estimating energy consumption for residential cooling installations in Detroit area. These curves, however, represent experience in one residence only, and more confirmatory information must be obtained from field operating results before the conclusion can be safely drawn that a satisfactory degree-day basis for cooling can be determined.

[5] "Summer Degree-Days for Predicting Air Conditioning Loads," by A. D. Marston, *Heating & Ventilating*, August, 1937, pp. 61–65.

An examination of Table 2 indicates that the number of hours and days when artificial cooling is required in a well-insulated residence is much less than has been generally estimated. In a climate like that prevailing in Detroit, hours of operation will probably not exceed 250 for the warmest summers, and days on which cooling is required will probably not exceed 30. In view of the rather short duration of the cooling season, the present average cost of installing either an ice or a mechanical cooling system in a residence is rather high. Fixed charges are three to four times as high as operating charges. First cost of the equipment is not as important an item in small commercial-office cooling as the load factor is much higher than it is for residences. Reduction in first cost of equipment will greatly enlarge the field for residential cooling.

CONCLUSIONS

(1) A furnace fan of the capacity usually installed, which is capable of circulating four to six air changes per hour, has no appreciable value for night-air cooling for residences, and is inferior to natural ventilation, unless the latter is restricted.

(2) A furnace fan circulating at least nine air changes per hour can accomplish appreciable cooling when circulating outdoor night air and has an advantage over the attic fan as it can circulate filtered air.

(3) An attic fan circulating 30 to 35 air changes per hour through the second-floor rooms is effective for night-air cooling and this size is as large as can be economically justified. The gain from circulating more than this amount is small.

(4) In residences, where cooling load comes largely from external sources, conventional methods of calculating heat transfer and cooling loads will give results about one third higher than actual maximum loads and correction should be made for a time lag in heat transfer caused by the heat capacity of the structure.

(5) Cooling a moderate-sized eight-room residence with a two-ton refrigerating machine is feasible if the climate is similar to that prevailing in the Detroit area and if the residence is well insulated and its windows shaded against sun effect. Detroit tests also show that a well-insulated six-room two-story residence of about 8500 cu ft volume can be satisfactorily cooled by a $^3/_4$-ton refrigerating machine.

(6) Ice cooling systems in residences and small commercial offices will operate satisfactorily, but prevailing prices for ice, $4 to $5 per ton, result in operating costs that are excessive and out of proportion to the benefits derived.

(7) Natural infiltration will provide sufficient outdoor air for the ventilating requirements of a residence under normal conditions of occupancy, and adding to the cooling load by bringing in outdoor air is not necessary.

(8) Number of hours and days that artificial cooling is required in a well-insulated residence is much less than has been generally estimated. In a climate like that prevailing in Detroit, this figure will probably not exceed 250 hr or 30 days for the warmest summers and for normal summers will probably not exceed 200 hr or 20 days.

(9) Present average cost of installing either an ice or a mechanical cooling system in a residence is rather high and seems out of proportion to number of days when it will be used in summer seasons such as Detroit's. Fixed charges are three to four times as high as operating charges. A reduction in first cost greatly enlarges the field for residential cooling.

(10) Comfort cooling of small structures, or a modified form of air conditioning, need not be expensive if designers give credit to the modifying effect of time lag in heat transfer, take advantage of insulation and shading of windows, and concede that maintaining optimum conditions at all times is not necessary.

Investigation of a Simple Form of HYDRAULIC DYNAMOMETER

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THE TYPE of dynamometer here considered should be of great interest to every engineer concerned with performance testing of prime movers. It is simplicity itself—cheap and easy for any shop to make—yet possessed of desirable operating characteristics.

A casing partly filled with water, in which a plain smooth disk revolves, is the simplest possible form of hydraulic dynamometer. As resistance of the rotor to rotation is caused by fluid friction of the water, this form is known as the viscous dynamometer. Not only is the viscous dynamometer simple and inexpensive to build, but it is also capable of excellent automatic regulation. Since its power-absorbing capacity varies nearly as the cube of the speed of rotation,[1] it is stable in operation, as contrasted with the grabbing tendency so frequently associated with prony brakes. This also insures great capacity at higher speeds but unfortunately renders the viscous type less suitable for uses involving high torque at low speeds, a field for which the much more complicated and expensive Froude type (1)[2] is especially adapted.

The special object of this investigation was to determine the effectiveness of various easily applied modifications intended to overcome this one handicap of the viscous type. To this end, tests were conducted under the author's direction, in the engineering laboratories of Princeton University (2). Models, Fig. 1, having rotors 5, 5.8, and 10 in. in diameter were tested under the following conditions: One rotor disk, completely submerged, casing full; water temperature maintained at 60 F; results given for hydraulic absorption only, the power absorbed by bearing friction having been determined and subtracted from the total in each instance.

For each modification tested, the horsepower absorbed was plotted on logarithmic paper against revolutions per minute, the slope of the resulting straight-line graph being the value of the exponent n in the equation

$$H = a N^n \qquad [1]$$

where

H = horsepower
a = a constant
N = revolutions per minute
n = an experimental constant, found to be 2.88 for the viscous types and 2.92 for the bladed types tested

Because 23 different modifications were tested over a range of speeds, the resulting curves were rather crowded together. For greater clarity, curves for only the viscous run and the most effective bladed combination in each rotor size are reproduced in Fig. 2. Compactness is gained by plotting the vertical scale to one half the horizontal scale.

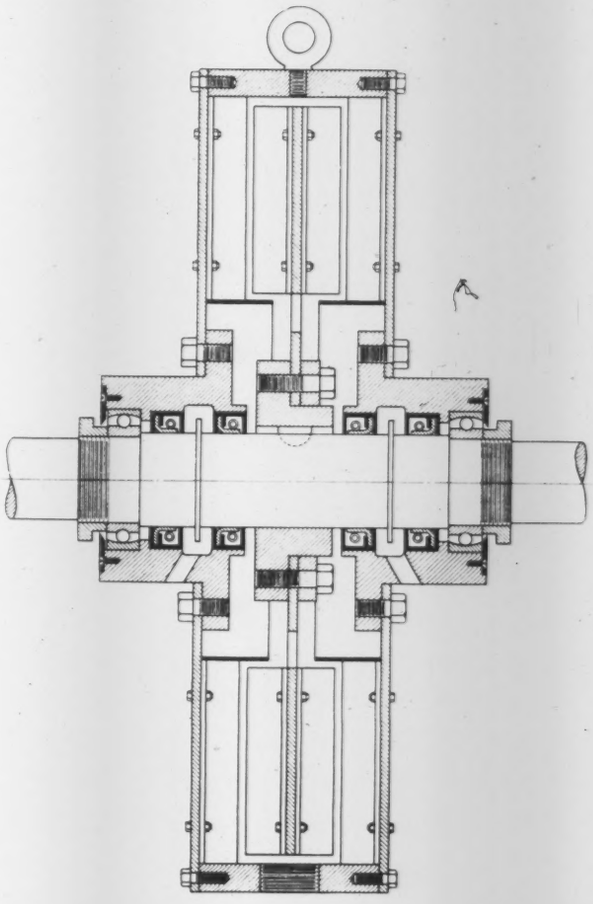

FIG. 1 HYDRAULIC DYNAMOMETER OF THE BLADED TYPE

Essential data obtainable from the original curves of all the runs are given in Table 1.

It will be noted that the columns denote, respectively, run number; rotor diameter; number of vanes on each face of the rotor disk; number of vanes on each side wall of the casing; actual horsepower, followed in parentheses by relative horsepower absorbed, considering the plain viscous of the same diameter to be 1.00. Unless otherwise designated by additional symbols, as shown in Fig. 3, the vanes project at 90 deg from the plane of the disk and are attached to it radially. Variations are shown in Fig. 3.

Table 1 indicates that the most effective design should have the largest diameter of rotor disk possible for a casing of given internal diameter. Right-angle vanes should be placed radially

[1] A.S.M.E. Power Test Codes, Internal-Combustion Engines, par. 22 (*b*).

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Hydraulic Division for presentation at the Fall Meeting, Erie, Pa., Oct. 4–6, 1937, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

TABLE 1 TEST RESULTS[a]

Run	Rotor: Diameter, in.	Rotor: Vanes	Casing Vanes	Horsepower at 500 rpm	Horsepower at 1000 rpm	Horsepower at 2000 rpm	n
1[b]	5.0	0	0	0.0008(1.00)	0.0060(1.00)	0.045(1.00)	2.88
2		8	0	0.0057(7.12)	0.043 (7.16)	0.31 (6.89)	2.87
3		8′	0	0.0059(7.37)	0.043 (7.16)	0.31 (6.89)	2.86
4		8	0*B*	0.036 (45)	0.292 (49)	2.25 (50)	2.88
5		8	0*A*	0.052 (64)	0.386 (64)	3.0 (67)	2.89
6		4	9*RB*	0.067 (84)	0.52 (87)	4.0 (89)	2.90
7		8′	9′	0.082 (102)	0.61 (102)	4.5 (100)	2.91
8		8_{30}	9	0.082 (102)	0.61 (102)	4.8 (107)	2.92
9		8	9	0.085 (106)	0.65 (108)	5.0 (111)	2.91
10		8	9*RPA*	0.088 (110)	0.70 (116)	5.6 (124)	2.92
11		8	9*RPB*	0.102 (128)	0.79 (132)	6.0 (138)	2.92
12		8	9*A*	0.105 (131)	0.82 (137)	6.7 (149)	2.90
13[b]		8	9*RB*	0.117 (146)	0.91 (151)	7.1 (158)	2.92
21[b]	5.8	0	0	0.00147(1.00)	0.0112(1.00)	0.083(1.00)	2.88
22		0	9	0.0040 (2.72)	0.024 (2.14)	0.14 (1.70)	2.56
23		8*s*	9	0.11 (75)	0.82 (73)	6.2 (75)	2.91
24		8*s*	9*R*	0.123 (84)	0.93 (83)	7.0 (84)	2.91
25		8	$9R_L$	0.137 (93)	1.02 (91)	7.6 (92)	2.91
26[b]		8	9*R*	0.14 (95)	1.10 (98)	9.0 (108)	2.93
31	10.0	0*H*	0	0.026 (1.02)	0.182 (0.99)	1.20 (0.86)	2.76
32[b]		0	0	0.0255(1.00)	0.184 (1.00)	1.39 (1.00)	2.88
33		8	0	0.198 (7.76)	1.45 (7.9)	10.0 (7.2)	2.83
34[b]		16	15*R*	2.3 (90)	17.0 (92)	....	2.90

[a] See Fig. 3 for explanation of symbols. [b] Plotted in Fig. 2.

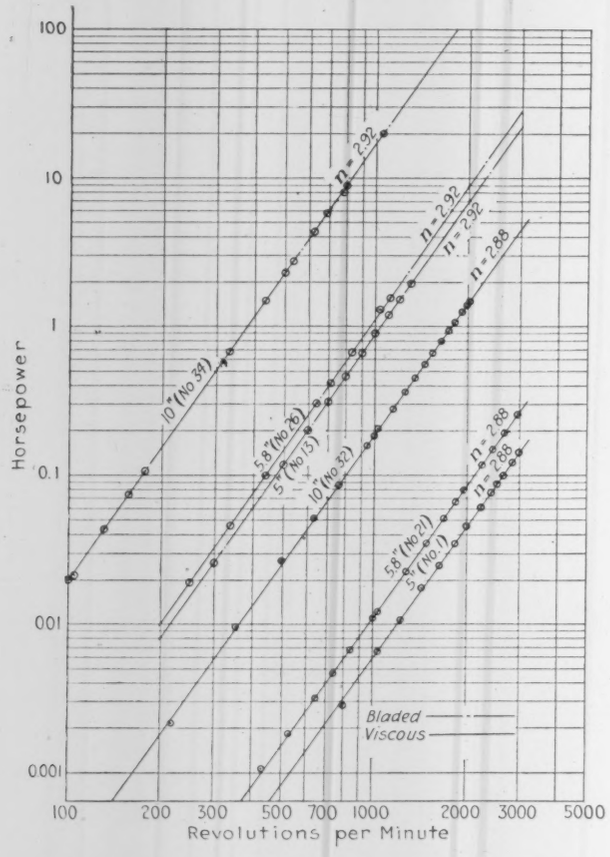

FIG. 2 CHART SHOWING HORSEPOWER ABSORBED PLOTTED AGAINST SPEED FOR DIFFERENT SIZES OF ROTOR

on the face of both the rotor and the casing. The discussion hereafter will be confined to this type of blading and to the plain viscous type for purposes of comparison.

To determine the variation of capacity versus rotor diameter, data from the curves in Fig. 2 were used to plot

$$H = bD^m \quad \ldots\ldots [2]$$

at speeds of 500, 1000, and 2000 rpm (Fig. 4). This was augmented by test results obtained from several larger dynamometers which we have in our laboratory, notably 16 and 24 in. viscous and a 24 in. bladed type, and by such published data as seemed to fit our test conditions as to type, conditions of testing, and reliability of data. Results obtained by the author are indicated by ⊙; those otherwise obtained, by ×. Because the number of bladed types for which reliable data were available was limited and they were not exactly homologous, the curves shown for the bladed types in Fig. 4 must be regarded as approximate only. They will, however, suffice to determine approximately the value of the exponent m for this type, at least until further data are available for the larger sizes.

The results of Fig. 4 now permit writing

$$H = \frac{6.6N^{2.88}D^{4.76}}{10^{15}} \quad \ldots\ldots [3]$$

for the viscous dynamometer and

$$H = \frac{1110\,N^{2.92}D^{4.4}}{10^{15}} \quad \ldots\ldots [4]$$

for the bladed type, where

H = horsepower absorbed, maximum
N = revolutions per minute
D = rotor diameter in inches

For practical use, these equations may be expressed in the more convenient form

$$H = \frac{CN^3D^5}{10^{15}} \quad \ldots\ldots [5]$$

for which the appropriate values of the coefficient C are given in Table 2.

TABLE 2 VALUES OF COEFFICIENT C

D, in.	Viscous, rpm: 500	1000	2000	Bladed, rpm: 500	1000	2000
5	2.13	1.96	1.80	258	244	230
10	1.80	1.66	1.52	170	161	152
15	1.63	1.50	1.38	133	126	119
20	1.52	1.40	1.29	112	106	100
25	1.45	1.33	1.23	98	93	88
30	1.38	1.27	1.17	88	83	78
35	1.34	1.23	1.13	80	76	72
40	1.29	1.19	1.09	74	70	66

It will be noted that the preceding equations ignore a number of factors affecting the capacity (3, 4, 5), among which may be mentioned

(1) Thickness of rotor disk (6)
(2) Effect of end and side clearances
(3) Degree of smoothness of disk and casing
(4) Viscosity of medium surrounding rotor
(5) Density of medium surrounding rotor

and for the bladed type, the following additional factors:

(6) Number of vanes
(7) Length and width of vanes

By dimensional analysis, as many of these variables as may

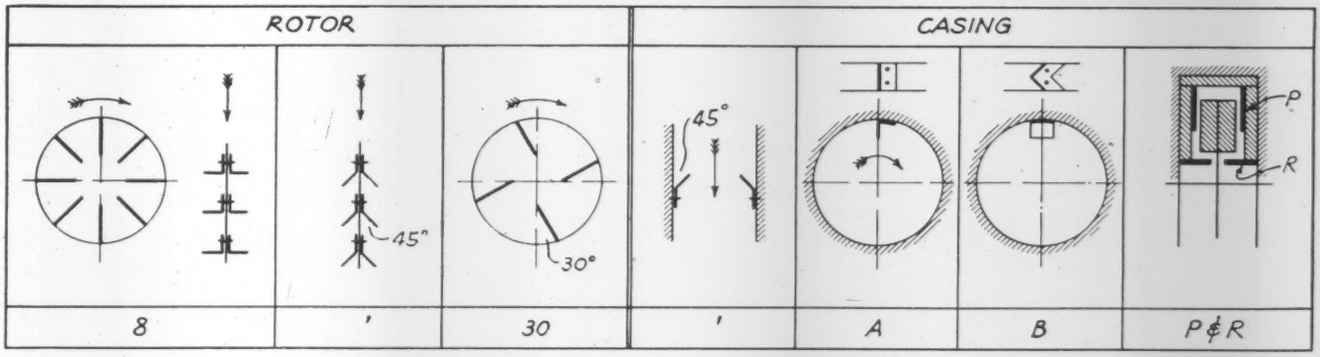

FIG. 3 EXPLANATION OF SYMBOLS USED IN TABLE 1

ROTOR

' = bent 45 deg
30 = placed 30 deg from radial
s = short vanes
H = 32 holes drilled through disk

CASING

' = bent 45 deg
A = nine straight circumferential vanes
B = nine V circumferential vanes
R = cylindrical rings
R_L = extra-long rings
P = annular plates

be desired can be incorporated in a dimensionless equation. Thus, for example, the form of the equation when speed, diameter, viscosity, and density are considered is as follows:

$$\frac{H}{\rho N^3 D^5} = K_1 \left(\frac{\zeta}{ND^2\rho} \right)^a \quad \ldots\ldots\ldots\ldots [6]$$

where

H = horsepower
ρ = density of the medium
ζ = viscosity of the medium
N = revolutions per minute
D = diameter of rotor
K_1, a = experimentally determined constants

Using the experimental exponents in Equation [3], a can be evaluated, and becomes 0.12, and, for the viscous dynamometer, Equation [6] simplifies to

$$H = K_2 \rho^{0.88} \zeta^{0.12} N^{2.88} D^{4.76} \quad \ldots\ldots\ldots\ldots [7]$$

This indicates that if the medium is water, raising its temperature through the practical range from 60 to 180 F, reduces H 13 per cent due to viscosity change (4), and 2.6 per cent due to density change. Similarly, for the bladed dynamometer

$$H = K_3 \rho^{0.92} \zeta^{0.08} N^{2.92} D^{4.4} \quad \ldots\ldots\ldots\ldots [8]$$

To permit investigating the influence of number of vanes, width of vanes, side clearance, and other factors, a special 10-in. experimental dynamometer was built. The circumferential casing was made of rings such that a variety of side clearances could be obtained between the rotor and the side casing. This rotor was driven directly by a six-cylinder Chrysler automobile engine rated approximately 70 hp at 3400 rpm. A series of 22 separate runs was made, in which the following were kept constant in all the tests: Rotor-disk diameter, 10.00 in.; thickness, 0.125 in. sheet brass; casing internal diameter, 10.25 in. sheet brass; and vane length $2^1/_2$ in. Vanes were placed radially and horsepower absorbed was the hydraulic absorption only, with the casing completely filled with water. The following factors were varied in the several runs: Number of vanes on each side of rotor disk, 0, 3, 6, and 12; Number of vanes on each face of casing was one less than the number of vanes on the rotor disk in each case; width of vanes $^1/_4$, $^1/_2$, and $^3/_4$ in.; and side clearance from $^1/_{16}$ to $1^5/_8$ in. Temperature of the water in the casing was kept at 70 F, except in several runs where it was desired to determine the loss in absorbing power

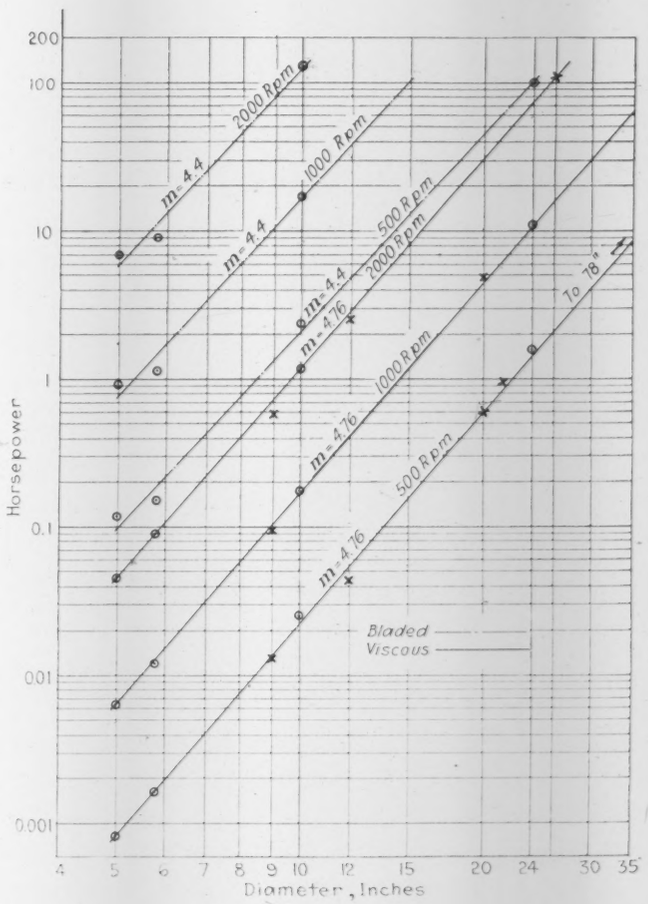

FIG. 4 CHART SHOWING HORSEPOWER ABSORBED PLOTTED AGAINST ROTOR DIAMETER

with rise of temperature. The speeds of rotation were varied from about 200 rpm up to as high as the engine at full throttle was capable of driving the particular dynamometer.

In addition, information was desired on the following: Possibility of filling the casing completely by gravity or funnel feed, approximate hydraulic pressure produced within the casing, and speeds of rotation of bladed types at which cavitation

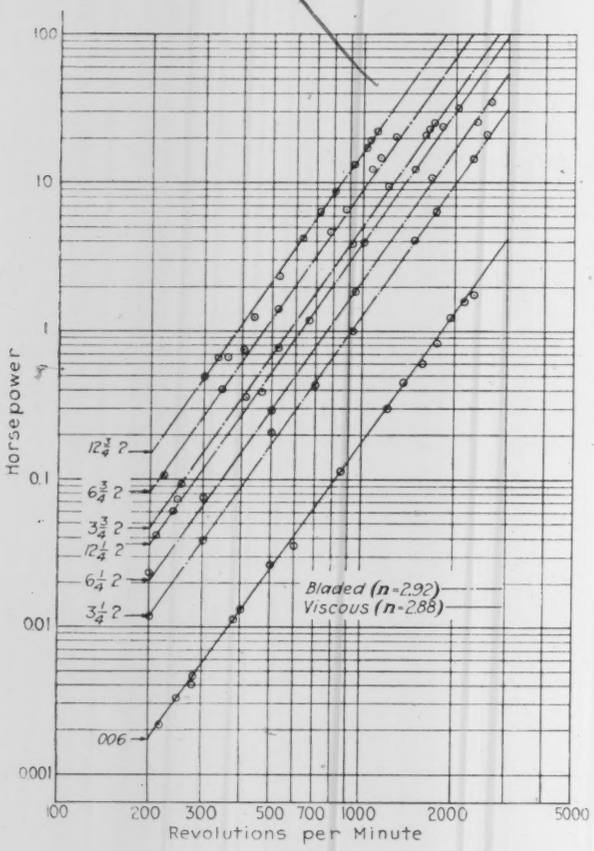

FIG. 5 CHART SHOWING HORSEPOWER ABSORBED PLOTTED AGAINST SPEED FOR DIFFERENT NUMBERS OF VANES ON EACH FACE OF THE ROTOR DISK, THEIR WIDTH, AND THE SIDE CLEARANCE

effects first appeared. To facilitate a logical designation for each run, a code was used indicating number of vanes on each face of the rotor disk, width of vanes, and side clearance in sixteenths of an inch, e.g., $12^1/_410$. In Fig. 5 the horsepower absorbed is plotted against speed for dynamometers 006, a plain viscous, $3^1/_42$, $6^1/_42$, $12^1/_42$, $3^3/_42$, $6^3/_42$, and $12^3/_42$. To avoid confusion in presenting these curves, the runs with $^1/_2$-in. clearance are omitted.

RESULTS OBTAINED

Value of the Exponent "n." For both viscous and vaned types of dynamometer, the values given in the original paper for n, the exponent of N in Equations [3] and [4], fitted the observed points in the present experiments satisfactorily.

Values of the Coefficient "C." The absorbing power, as computed from Equation [5], using coefficient values given in Table 2, checked almost exactly with results obtained in runs 006 and $12^3/_42$, respectively. This would indicate that for small sizes, at least, the equations originally given can be used with confidence.

Effect of Number of Vanes "v." In the case of both the $^1/_4$ and $^3/_4$-in. vanes, doubling the number of rotor vanes, from 3 on each face of the rotor to 6 and also, from 6 to 12, increased the absorption 1.8 times. This may be expressed exponentially as

$$H = C'v^{0.85} \quad [9]$$

where

H = the horsepower absorbed, C' a constant, and v the number of vanes on the rotor

Effect of Width of Vanes "w." Tests on the dynamometer with $v = 3$, 6, and 12 indicated that increasing the width of vanes from $^1/_4$ to $^1/_2$ in. increased the absorbing power 2.2 times, while increasing from $^1/_4$ to $^3/_4$ in. increased the capacity fourfold. This relationship may, therefore be approximately expressed as

$$H = C''w^{1.2} \quad [10]$$

Effect of Side Clearance. Runs were made with the viscous dynamometer having side clearances of 1, 10, 17, and 26 sixteenths of an inch and with selected vane types having 2, 10, and 17 sixteenths clearance. The difference in holding power resulting from these changed side clearances was too small to justify any numerical expression for this effect, but, in general, the power tends to increase slightly with increased clearances.

The conclusion was drawn that the effect of any side clearance likely to be used in practice is negligible in comparison with the other factors. However, types having the greatest number of vanes and the least side clearance were observed to produce a noise at high speeds, which was absent with more generous clearances.

Effect of Water Temperature. A marked reduction in capacity was observed with increase in water temperature. The viscous dynamometer 006 lost about 1 per cent in absorption power per 5.3 F rise and the vaned types, $12^1/_42$ and $12^3/_42$, lost approximately 1 per cent per 13 F rise.

Pressure Produced Inside the Casing. If the water at the periphery of the rotor is assumed to have a tangential velocity equal to that of the rotor circumference, the theoretical centrifugal head is $ht = v^2/2g$ which may then be conveniently written

$$pt = 1.305\,(10^{-7})D^2N^2 \quad [11]$$

where

pt = theoretical internal pressure, lb per sq in.
D = rotor diameter, in.
N = rotor speed, rpm

A sensitive test gage was mounted on the side of the casing, at a radius of 5 in. Observations over the speed range of 400 to 2500 rpm showed the 10 in. viscous dynamometer to have an internal pressure p of

$$p = 1.48\,(10^{-7})\,D^2N^{1.77} \quad [12]$$

which at 1000 rpm gives $p = 0.23\ pt$, and at 2000 rpm $p = 0.20\ pt$.

Similar tests with the 10-in. vaned dynamometer $12^3/_42$ over the speed range of 220 to 1000 rpm showed that the observed pressure increased as $N^{2.50}$ up to about 700 rpm but above that rotor speed it followed Equation [13].

$$p = 1.12(10^{-7})D^2N^2 \quad [13]$$

showing $p = 0.86\ pt$.

These observations would indicate that the internal casing pressure may safely be assumed to be not over 25 per cent of the theoretical for viscous dynamometers and 100 per cent for the vaned types.

Gravity Filling. Experiments were conducted with gravity filling of the casing to determine how nearly full it was practical to run the casing by this method of filling. In every instance tried, the curves of horsepower absorbed coincided with those obtained by pressure filling, showing that it is possible in practice to use the funnel-filling scheme which are suggested in the concluding paragraphs of this paper and attain full absorption.

Cavitation. Theory would lead to the conclusion that as the speed of rotation of a certain vaned rotor was increased more and more, a point would finally be reached where the horsepower absorbed would no longer increase at the same rate as at the lower speeds. Presumably, the greater the number of vanes on a certain rotor, or the greater the width of these vanes, the lower would be the speed at which cavitation effects would appear. It was hoped to secure some quantitative results on cavitation effects or the limit above which it is likely to be present, but this was found to be impossible in the present experiments, because in no case did the automobile engine which was used have sufficient power to drive the experimental dynamometers up to a high enough speed for cavitation to set in.

PRACTICAL CONSIDERATIONS

For engine testing, the mechanical design shown in Fig. 1 has been found most satisfactory. Where the dynamometer must be self-supporting as a unit, providing antifriction bearings to support the dynamometer shaft is simplest. When bolting the dynamometer shaft directly to the engine under test is permissible, an outboard bearing carrying the other end of the shaft is all that is necessary. The rotor disk and the casing side plates in the smaller sizes, say up to 12 in., may be of sheet brass; for the larger sizes, boiler plate, flame-cut to size, avoids the need of machining large diameters and has been found entirely satisfactory. The casing ring may be rolled from boiler plate and welded. Blades may be conveniently made

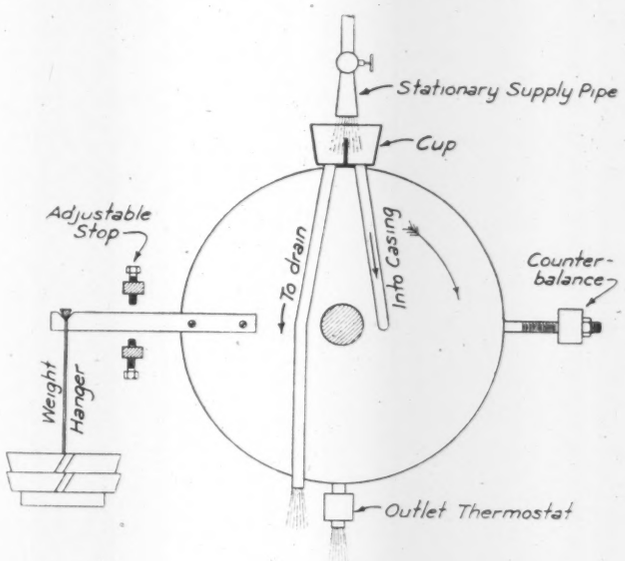

FIG. 6 AUTOMATIC BALANCING SCHEME DEVELOPED BY THE AUTHOR WHICH GREATLY INCREASED CONVENIENCE AND PRECISION OF THE DYNAMOMETER OPERATION

from short lengths, about $D/4$ long, of commercial angle iron, but, when this cannot be easily obtained in small enough sizes, brass strip can be readily bent to shape in a vise.

Self-regulating features originated by the author add greatly to the convenience and precision of operation of either viscous or bladed type and are shown in Fig. 6. The supply is allowed to run into a cup mounted on the upper part of the dynamometer casing. This cup is provided with a dividing wall, making two separate compartments; one leading into the casing and the other directly to a drain. By permitting the dynamometer casing to have a slight angular motion and balancing its torque by an arm carrying a weight hanger, the action is as follows: When the casing is insufficiently filled to lift the weights under the conditions prevailing, water from the stationary supply pipe flows into that side of the cup leading to the casing. When sufficiently filled, the casing will move slightly in the direction of shaft rotation, moving the cup to permit part of the supply water to enter that side leading directly to the drain. The divided cup thus acts as an accurate metering device, admitting water at the precise rate required to keep the dynamometer balanced. For dynamometers which are intended to operate in either direction, the metering cup should contain three compartments, the two end ones leading to drains.

To insure proper admission of water, the casing should be well vented by a tapped hole placed at as small a radius as possible on the side of the casing opposite that into which the water enters. Venting is facilitated by fitting the vent hole with a pipe or tube extending downward to provide a syphon action whenever water overflows through it. Venting is also improved by providing several small holes through the rotor disk near the hub. The outlet from the bottom of the casing should be provided with a thermostat of the type used in automobile cooling systems, automatically preventing the dynamometer from exceeding a satisfactory operating temperature.

The equations given are for the limiting capacity of dynamometers completely filled with cool water. As all these conditions are not fulfilled in a conservative design intended for practical engine testing, experience dictates using for this purpose a coefficient C of one third the tabulated value. It is also of importance to note that the size of the rotor is usually controlled by the power to be absorbed at the lowest test speed.

In conclusion, the author wishes to express his thanks to his colleague, Dr. R. H. Wilhelm, for the relationships derived by dimensional analysis.

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Earnings of Engineers

(*Continued from page 742*)

entials in earnings, however, did not accrue in equal measure for all five professional classes.

At about 28 years of age the "other" engineers had lost an initial advantage in earning capacity. At that point, the 1929 earnings of the graduates ranged from $2725 to $3000 per year, those of the corresponding "other" engineers from $2430 to $2650.

With advancing age, the spreads in earnings in favor of the graduates became very marked indeed. For example, at 5, 20, and 37 years after graduation, the earnings of first-degree mechanical and industrial engineers exceeded by $175, $925, and $1322 per year those of the engineers of the same professional class whose college course was incomplete, and surpassed by $225, $1160, and $1815 per year those of engineers with a noncollegiate technical-school education.

Even among the graduate groups there was variation in the increase in earning capacity between the several professional classes. Thus, the 1929 earnings of first-degree civil engineers who had been out of college for five years were only $2050 less than the earnings of those who had graduated 30 years before, whereas the corresponding difference for chemical and ceramic engineers was $3600. The ranges in earnings of the remaining graduate groups fell between those reported by the civil and chemical and ceramic engineers.

In general, the earnings of the "other" engineers ceased to increase at an earlier age than those of the graduates.

The present study gives conclusive demonstration of differences of income which generally reflect different degrees of capacity. The lot of the college graduate may be somewhat easier than that of the nongraduate. But even in 1929 the lowest 10 per cent of the college graduates in civil engineering were earning less than $2500 after 10 years of experience and $2700 after 20 years of experience. These figures are to be compared with the average earnings of $3600 and $4400 for these respective groups. On the other hand, the upper 10 per cent of the civil engineers whose college course was incomplete earned $5200 or more after 10 years of experience and $7600 or more after 20 years of experience. The upper 10 per cent of the engineers with only a secondary-school education similarly show earnings substantially above those of the average college graduate.

In other words, graduation from an engineering school is no guaranty of a satisfactory income, while there is still apparently an opportunity for a man of outstanding capacity to secure far better than an average engineering income even though he has not attended college.

The most significant differences in income revealed by the present survey are not the differences in the average income received by individuals who have received a college degree and those who have not. Nor are they the differences as between individuals who have entered one professional class rather than another. These differences on the whole are moderate, though they are large enough to prove the desirability of choosing well both the field of endeavor and the type of training best adapted to advancement in that field. The most striking differences are those which exist within each profession and within each group classified on the basis of its educational background. One out of 10 of the engineers in each such group secures an income several times as great as the average for the group as a whole. At least one out of 10 at the bottom of each such group, whether a college graduate or not, whether a chemical engineer or a civil engineer, whether a man with many years of service or one freshly out of college, is hardly to be distinguished as regards income from a skilled wage earner.

We do not feel ourselves competent to project from these data what the future holds in store for the high-school boy who must be advised as to what type of training will be most advantageous. We hope he may be fortunate enough to encounter wise advice. We dare do no more than point out that in 1929 the average income of graduate engineers with 10 years' experience ranged from $3600 to $4600 in the various professional classes. In 1929 only 6.4 per cent of the incomes in the United States exceeded $4000. Furthermore, engineering is a profession in which earning capacity advances and is sustained until late in life. But if in these respects the profession appears attractive on the average, its rewards are not particularly attractive to the poorer or less fortunate engineers. Even in 1929 the lowest-paid 10 per cent of the engineers could hope for no more than $2500 to $3000, though they might stay in the profession for 40 years. In 1934, exposed as the profession was to the risks of unemployment, the lowest paid 10 per cent of the engineers with less than 5 years' experience after graduation earned less than $1000. Even with 10 to 30 years' experience they earned no more than $1000 to $1500. Judged from the basis of money income, there can be no question but that the best of a group of skilled wage earners are in a better economic position than those who struggle to maintain a position on the fringes of the engineering profession.

The Langley "Whirling Table"

(*Continued from page 732*)

28 rpm, was attained. Models of various forms of wing surfaces or "mechanical birds" made of cork, tin, and rubber were mounted on the tip with freedom to move vertically so that the variation of lift with different shapes, speeds, and angles of attack could be studied.

On the completion of his experiments, Dr. Langley had the whirling table dismantled and destroyed. He failed to appreciate the historical and scientific significance of his apparatus and had it removed from the grounds of the observatory as an encumbrance and eyesore.

THE MODEL

In preparing the Langley exhibit the university authorities called upon William R. Ludewig, instructor in machine-shop practice, who had worked as a mechanic for Dr. Langley in the building and operation of the whirling table. From materials in his possession, Mr. Ludewig was able to make a model of the whirling table in its proper setting on the observatory grounds. This model, built on a scale of one inch to the foot, is a remarkable piece of realistic reproduction. The building is not only correctly constructed to scale but the walls consist of photographic reproductions of the original brickwork, showing the weather stains, the steps, rain spouting, and even such trifling details as a couple of broken window panes. The whirling table is constructed with the same attention to details, showing the model to be tested in its place on the tip, the engine with its belt drive, and even a miniature coal pile, shovel, hose, and water barrel. The building of this model occupied the spare time of Mr. Ludewig and his assistant, Ivan A. Gradisar, throughout several months.

The model is on exhibition in the University's "Cathedral of Learning" and has been viewed by thousands of visitors.

INTERCHANGEABLE MANUFACTURE

By J. W. ROE

NEW YORK UNIVERSITY, NEW YORK, N. Y

BY INTERCHANGEABLE manufacture we mean the production of complete machines or mechanisms, the corresponding parts of which are so nearly alike that they will fit into any of the given mechanisms. We are apt to think of it as a rather definite thing. In fact interchangeability is utilized in a varying degree by different industries. In some it is a major objective, of great value to the ultimate user of the product in repairs and to the manufacturer in assembling, as in military firearms and automobiles. In others it is important to the manufacturer but of little or no interest to the user, as in Waterbury watches. In still others it may be only incidental, as will be seen in the Portsmouth pulley blocks. This last is primarily mass production. Minor advantages of interchangeability in such a simple assembly come as a by-product of machine production and are hardly utilized by the final user at all.

Interchangeable manufacture began with military firearms. This field was the only one at that time which had all the conditions calling for it, namely, large quantities of the same design, where uniformity and facility for repairs were major considerations. If a lock were broken, the gun was useless until some skilled armorer either repaired it or made some new part and fitted it into place. Even in England where skilled workmen were most available not enough armorers were available to meet the demand, and in 1811 the government had on hand 200,000 musket barrels which were useless for want of men to make or repair the locks.

Fitch states in his report in the U. S. Census of 1880[1] that

> Sample guns, with parts to interchange, were made in France as early as 1717, and again in 1785, at each of which dates the attempt to reduce this desirable feature to a practical manufacturing result failed, presumably through prejudice, improper system, and lack of machinery.

Thomas Jefferson, who seems never to have missed a trick, wrote[2] home about this last attempt while he was minister to France. He went to the workman who proposed it, LeBlanc was his name, and was presented with the parts of fifty locks taken to pieces and arranged in compartments. In part the latter reads

> I put several together myself, taking pieces at hazard as they came to hand, and they fitted in the most perfect manner. The advantages of this, when arms need repair, are evident. He effects it by tools of his own contrivance, which, at the same time, abridge the work, so that he thinks he shall be able to furnish the musket two livres cheaper than the common price. But it will be two or three years before he will be able to furnish any quantity.

ELI WHITNEY

Due credit should be given to LeBlanc for he was apparently on the right track, but for some reason nothing came of it, either in France or in Jefferson's effort to have him brought over to the United States.

FIREARMS—THE FIRST AMERICAN EXAMPLE

Thirteen years later the real development of interchangeable manufacture began. Eli Whitney, who had invented the cotton gin in 1792, realized that he could not make any money from it. With the patent laws as they then were he could not defend his rights as inventor, and he therefore turned to the manufacture of an unpatented article by what he called "a new and improved method."

In January, 1798, he obtained a contract for 10,000 muskets at $13.40 each, 4000 to be delivered the first year and the remainder one year later. Whitney says in a letter[3] to the Secretary of War in May, 1798

> I am persuaded that machinery moved by water, adapted to this business, would greatly diminish the labor and facilitate the manufacture of this article. Machines for forging, rolling, floating, boring, grinding, polishing, etc., may all be made use of to advantage.

He says in another place[4] that he aimed "to make the same parts of different guns, as the locks, for example, as much like each other as the successive impressions of a copper-plate engraving."

Whitney was longer in getting his new methods into operation than he anticipated. He delivered only 500 guns in the first year, and it was eight years instead of two before he completed the contract, but he adhered to his new methods and the standard he had set. About 1800, when the Army officials were becoming uneasy over the delay, he took the parts of ten guns to Washington and assembled them without fitting, selecting the parts indiscriminately from each pile to the amazement and satisfaction of all. Captain Wadsworth in a letter to the Secretary of the Treasury, about 1800, says the principle of interchangeability, "was a favorite idea with Mr. Whitney from the beginning." A year later Jefferson writing[5] to Monroe says

> He has invented molds and machines for making all the pieces of his locks so exactly equal, that take 100 locks to pieces and mingle their

[1] "Report on the Manufacture of the United States at the Tenth Census (June 1, 1880)," Government Printing Office, Washington, D. C., 1883, p. 618.

[2] "The Writings of Thomas Jefferson," edited by H. A. Washington; Taylor & Maury, Washington, D. C., 1853, vol. 1, p. 412.

Address delivered at the Thirteenth Annual American Dinner, New York, N. Y., April 21, 1937, of the Newcomen Society for the Study of the History of Engineering and Technology.

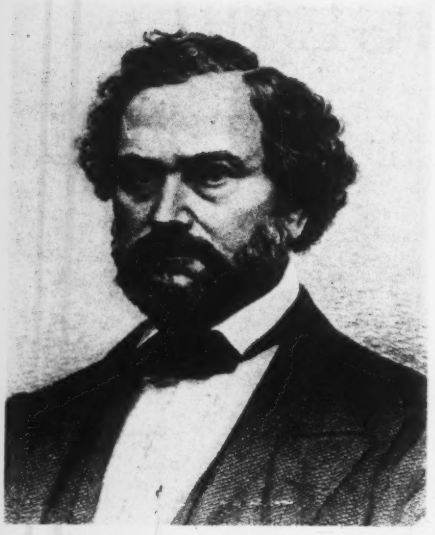
[3] "Sketch of the Life of Eli Whitney," by W. P. Blake, Papers of the New Haven Colony Historical Society, 1894, vol. 5, p. 117.

[4] "Memoir of Eli Whitney, Esq.," by Denison Olmstead; Durrie & Peck, New Haven, Conn., 1846, p. 50.

[5] "The Writings of Thomas Jefferson," edited by P. L. Ford; G. P. Putnam's Sons, New York, N. Y., 1897, vol. 8, p. 101.

parts and the hundred locks may be put together as well by taking the pieces which come to hand.

In October, 1798, nine months after Whitney's contract, Simeon North, a gunmaker of Berlin, Conn., and later of Middletown, received a contract for 500 pistols, followed two years later by one for 1500. Like Whitney, he began utilizing division of labor, putting parts through in lots and using jigs, gages, and machinery. Soon each armory was employing about sixty men, one plant making muskets, the other pistols. In 1812, Whitney was given another contract for 15,000 muskets. In applying for it, he stated that the work would be carried out upon the plan which he had used "for the last 12 years."



SAMUEL COLT

The next year, 1813, North received a contract[6] for 20,000 pistols, at $7 each, which contained this clause, "the component parts of pistols are to correspond so exactly that any limb or part of one Pistol may be fitted to any other Pistol of the twenty thousand." This is claimed, and probably rightly, to be the first contract with a clause specifying interchangeability. It does not, however, mark the beginning of a new method, but rather the first contractual recognition of methods that had already come into use and were well-established in the shops of both men.

PRODUCTION OF PULLEY BLOCKS AT PORTSMOUTH DOCKYARD

So far we have been tracing the beginning of a type of manufacture where interchangeability was important to the ultimate user. Meantime, across the turn of the century, a fine example of mass production by machinery was being developed in England, where interchangeability was not the chief objective. Sir Samuel Bentham, brother of Jeremy Bentham the economist, and a brilliant example of the naval official at his best, turned his attention to woodworking machinery and took out a remarkable patent in 1793. This led him to recommend a government factory to produce pulley blocks, of which the Admiralty used 100,000 yearly. The recommendation was approved and a plan of production had been developed and work begun, when Bentham met Marc Isambard Brunel, a French naval officer of the old royalist régime who had escaped the revolutionists and spent six years in the United States, where he became a citizen. He worked on the Hudson-Champlain Canal and various river improvements, submitted a plan for the city of Washington in competition against his friend Major L'Enfant, and had a hand in planning the fortifications of New York harbor.

In a conversation at Alexander Hamilton's dinner table, his attention was turned to the production of pulley blocks, and he began working on machinery for this purpose. Soon afterward, he went to England where he remained for the rest of his life. He laid his plans before Lord Spencer of the Admiralty and Sir Samuel Bentham. Bentham, who was wholly free from official jealousy, at once saw the superiority of Brunel's plans over his own and broadmindedly recommended them for adoption. Brunel was commissioned to install the machines in a plant at the Portsmouth dockyard. The work was executed by Henry Maudslay who contributed many of his own ideas in their practical development.

In all, 44 machines were used and arranged in four groups for

(1) Sawing and roughing the blocks
(2) Boring, mortising, and finishing the blocks
(3) Turning, boring, and finishing the sheaves
(4) Forging, turning, and finishing the pins.

In addition, several machines were installed for making "dead eyes" or blocks, without sheaves, used in the fixed rigging.[7] These machines were thoroughly modern in their conception and constituted a complete range of tools, each performing its part in an articulated set of operations. With this machinery 10 unskilled men did the work of 110 skilled workmen. The plant was in full operation by 1808 with an output of over 130,000 blocks a year, which was greater than the previous output of the six largest dockyards, and it continued to supply all the blocks for the Royal Navy for many years, in fact, until wooden blocks made way for iron and steel ones.

Here was a well-developed and successful example of mass production, where interchangeability is not even mentioned as an objective in any description of it. The Portsmouth block machinery was widely known and pointed to with just pride, but it had little, if any, influence on the adoption of interchangeable manufacture in England. This did not come until nearly fifty years later with the introduction of the Enfield machinery from America.

INTERCHANGEABLE MANUFACTURE APPLIED TO CLOCKS AND WATCHES

In an intermediate type of quantity manufacture interchangeability is not important to the user but is to the manufacturer. The next advance was made in this field. Eli Terry, a Connecticut clockmaker, like others of his day had been making clocks by hand, a few at a time. He would then make two or three trips a year on horseback to "the New Country," as it was then called, just across the North River, taking with him three or four clocks, which he would sell for about twenty-five dollars apiece.[8]

Influenced, we are told, by Eli Whitney he bought an old mill at Plymouth, Conn., and in 1807 he fitted it up to make wooden clocks by machinery. He contracted to make 4000 clocks the next year, but a year was required to prepare for production. By the second year he had finished 1000 and by the third year had completed the contract. In 1810 Terry sold his little plant and shop rights to Seth Thomas and Silas Hoadley, two of his workmen, but he continued in business himself. In 1814 he invented a new 30-hour, wooden-movement shelf clock, and soon he and Thomas were making 6000 clocks a year, increased in a few years to over ten or twelve thousand.

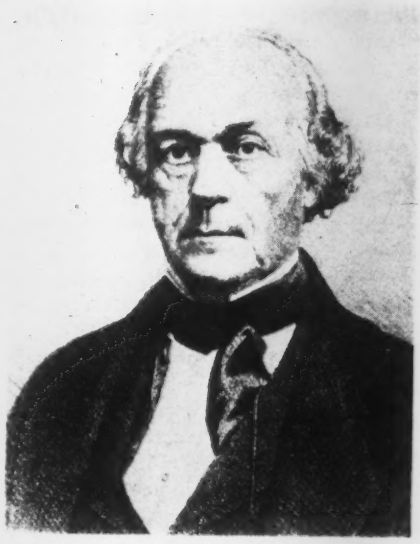
[6] "Simeon North, First Official Pistol Maker of the United States," by S. N. D. and R. H. North, The Rumford Press, Concord, N. H., 1913, p. 81.

[7] "Memoir of the Life of Sir Marc Isambard Brunel," by Richard Beamish; Longman, Green, Longman, and Roberts, London, 1862, p. 342.

[8] "History of the American Clock Business for the Past Sixty Years," by Chauncey Jerome; F. C. Dayton, Jr., New Haven, Conn., 1860, p. 36.

During this time Terry reduced the price of wooden clocks from $25 to $5. He first systematized the work on the movements and then, with the increasing sale of his shelf clocks, he began to apply the same principles to the manufacture of the cases. This clock was manufactured in large quantities for 30 years, until supplanted by brass ones. Terry introduced quantity production of wooden clocks. Like Eli Whitney, he never patented any of his equipment, and his methods spread to Waterbury, Bristol, and elsewhere. He retired in 1833, well-to-do, and died in 1852.

Joseph Ives, of Bristol, Conn., invented a metal clock with cast brass wheels in 1818. By 1832 he had worked out an eight-day, rolled-brass clock movement, but the art of rolling sheet brass had not advanced enough to take full advantage of it before 1840. By that time Chauncey Jerome, who like Thomas had learned machine production from Terry, had developed a 30-hour rolled-brass clock that was cheaper than either Ives's eight-day cast-brass clock, costing about $20 or Terry's 30-hour wooden clock costing about $5. By machine methods these were eventually made at a cost of less than 50 cents, were being exported to England by 1840, and by 1855 were being produced at a rate of 400,000 a year.



CHAUNCEY JEROME

Through all of this, one hears little or nothing of interchangeability. But, while the principle was utilized hardly at all for repairs, it was used by the manufacturer in production and assembly so effectively that the cost of clocks was reduced to a point where it was cheaper to buy a new clock than repair an old one.

In 1848, Aaron L. Dennison first attempted to manufacture watches by machinery. This was first done successfully by the American Watch Company at Waltham, Mass., where interchangeable methods were used for all the parts except the jewel pivots, balance, and hairsprings. A whole new line of special machines gradually extended mass-production methods down to finer work than ever before attempted. As a single example, Fitch reports in 1880 the production of parts requiring 25 operations, weighing 1/130,000 lb, with 260 threads per inch, which were produced for 2.27 cents each.[9] In this field interchangeability made steady headway and is now used with practically all watches produced.

GUNS AND REVOLVERS SPEED ADOPTION OF INTERCHANGEABILITY

During these years, while the field of interchangeable manufacture was widening the gunmakers still led the way. Whitney was called on to help introduce it at Harpers Ferry and Springfield. Blanchard introduced woodworking machinery at Springfield, including his lathe for turning gunstocks and other irregular shapes, until the accuracy of the operations on the stocks overran that on the metal parts, and they had trouble bringing them into step. In 1815, on Colonel Wadsworth's recommendation, model muskets were distributed to the different armories, government and private, to be followed as models "and no deviations from the pattern were to be allowed." In 1824 one hundred rifles from various armories were brought together, taken down, and reassembled at random. After the Seminole War in Florida, a large number of damaged carbines were repaired at Watervliet, N. Y., and the parts, old and new, were reassembled without difficulty. Use of limit gages was greatly extended and improved. Filing of pieces in contoured, hardened jaws, which was deadly on files, gave way to milling. Drilling jigs and the drop hammer were introduced, and receiver gages were in use by 1840.

Shops were springing up where interchangeable methods were thoroughly understood, which made machines and gages for producing upon this basis. The American Mfg. Co., Chicopee, Mass., and George S. Lincoln & Co. in Hartford, Conn., were two, but the outstanding leaders were the Colt Armory at Hartford and the Robbins & Lawrence Company at Windsor, Vermont.

Colt invented his revolver in 1835. It was turned down by an Army board, as nearly every civilian invention has been, but its record in the Seminole and Mexican wars secured belated approval and substantial orders. His first revolvers were made under contract at the old Whitney armory in New Haven. Because of his rapidly growing business Colt decided to build his own plant. He moved to Hartford in 1848 and in 1853 began work on the Colt Armory, which was finished in 1855, a date that marks an epoch in American manufacturing.

Colt was not a great mechanic, but he was a daring and brilliant manufacturer. Thoroughly alive to the advantages of interchangeable manufacture as he had seen it at the Whitney shop, he determined to carry it even further in his new plant. Although only just starting he outbid three others to bring Elisha K. Root down from the Collins Company, axe makers of Collinsville, Conn., at a salary reputed to be $25,000 and turned him loose with a free hand. The Colt Armory, which Root built, was the most influential shop in the country, certainly of that time. It is still one of the leading gun factories of the world and is a monument to a great mechanic. He utilized the best tools available and designed many new ones, some of them still in operation. Every process felt his influence. He invented the best form of drop hammer then in use, as well as machines for boring, rifling, making cartridges, stock turning, splining, and similar operations, and worked out the whole system of jigs, fixtures, tools, and gages. Over 1400 machines were installed, and the cost of the special tool and gage equipment exceeded that of the machines, a proportion unheard of up to that time. No handwork at all was allowed. Even the smallest burring operation was done by machine. Critics said he had gone crazy, but the result was a brilliant success, both mechanically and financially. Colt's revolver has practically disappeared, but the way Root made it has spread everywhere.

The other leader was the old Robbins & Lawrence shop at Windsor, Vt., which was never very large and was tucked down by a water power in the upper Connecticut valley. From a small private gunshop it had developed into the design and production of machine tools for interchangeable manufacture. Here Frederick W. Howe, R. S. Lawrence, and Henry Stone developed the turret lathe, plain milling machine, and many of the new tools used by Root. It has gone through a

[9] "Report on the Manufactures of the United States at the Tenth Census (June 1, 1880)," Government Printing Office, Washington, D. C., 1883, p. 680.

checkered history of more than 100 years, through various changes of name, from great prosperity to bankruptcy and back again several times, and produced more great mechanics than almost any plant in the country, all of them conspicuous in the field of interchangeable manufacturing. Its greatest contribution has been the turret lathe, and its successor, the Jones & Lamson Machine Co., still holds a leading position.

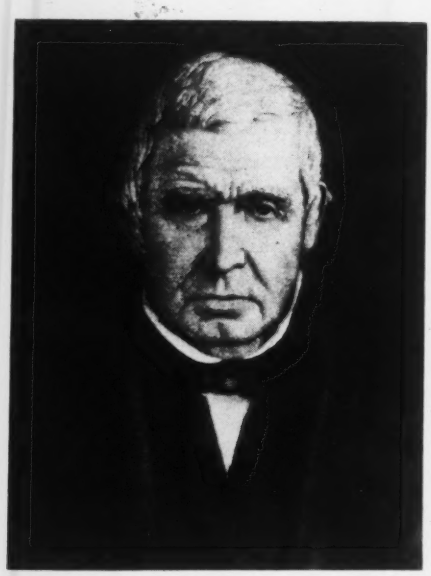
As a result of the exhibits of Colt and Robbins & Lawrence at the Great Exhibition of 1851 in London, a Small Arms Commission, of which Sir Joseph Whitworth was a member, visited the government and private armories in this country in 1853. Upon their recommendation the British government resolved to introduce "the American System."[10] An order was placed with Robbins & Lawrence and The American Mfg. Co. for 20,000 Enfield rifles, and a full equipment of tools and gages for the new Enfield Armory. For the next 30 years these and other New England manufacturers, notably the Pratt & Whitney Co., equipped armories for practically all the governments of the world. Interchangeable manufacture spread everywhere. From then on it was made the basis of production as new products arose to which it is adapted.

PRODUCTION OF SEWING MACHINES AND AGRICULTURAL MACHINERY

During the 1850–1860 decade, another industry was springing up. Howe invented his sewing machine in 1846. In quick succession Wilson, Singer, and Gibbs followed with theirs, and in a few years the clothing industry provided a market where interchangeability was important. As with most valuable inventions, a furious patent litigation sprang up which was settled by an agreement for cross-licensing and the familiar huddle of the insiders to shut out newcomers. This centered most of the manufacturing in the hands of a few large, prosperous plants, which adopted all of the tools and technique the gunmakers had developed and applied them to complicated forgings, castings, wooden parts, needles, and other parts, a much wider range than is present in firearms. From its very beginning the sewing-machine industry was developed on the basis of interchangeable manufacture and greatly widened its application.

About this time, perhaps a little later, agricultural machinery applied the method to a much rougher product, but one where interchangeability was important for repairs. Many of the parts of mowers, reapers, and other machines, which were subject to breakage, were beyond the capacity of farmers and local blacksmiths to repair, and ability to obtain replacement parts from agents was a factor of importance. After the Civil War interchangeable manufacture had become the accepted basis of production for all high-grade products made in quantity. When typewriters came along in the early '80s and bicycles in the '90s it was used as a matter of course. In these, as in firearms and sewing machines, it not only made a refined and interchangeable product but permitted manufacture at astonishingly low costs.

[10] "James Nasmyth, Engineer, an Autobiography," edited by Samuel Smiles; John Murray, London, 1883, pp. 362 and 363.



ELI TERRY

AUTOMOBILES EXERTED GREATEST INFLUENCE

After firearms, the product that has had most influence on interchangeable manufacture has been the automobile, and those of us who drove, rode, or crawled under an automobile thirty years ago know what interchangeability has done for it. All the early cars in Europe and this country were *built*. It was not until 1902 or 1903 that real manufacture began. R. E. Olds produced approximately 2500 of his one-cylinder, curved dash, tiller-steered runabouts in 1902; 4000 in 1903, and 5000 in 1904. Henry Ford's production passed this by 1906 and in 1909 had reached 10,607.

Like the older sewing-machine industry the automobile industry adopted interchangeable manufacture and extended it to still larger parts, such as crankshafts, cylinder blocks, and fenders, all produced in amazing quantities. It made steadily rising demands on the toolbuilders and metallurgists and called into being new machines, such as precision gear cutters, precision grinders of all types, station-type chucking machines, and presses for stamping and forming chasses, fenders, and bodies. We all know the results. Probably nowhere does one get so much for his money as in the present-day automobile. Of all the products of modern industry the automobile has pushed interchangeable manufacture farthest, and to the benefit of the widest public.

Glance back for a moment and see the effect of interchangeable manufacture on the tools of production. The milling machine was developed by Whitney and North before 1820, and improved by Howe and Lawrence and many others, drop forging by Hall at Harpers Ferry, the lathe for irregular turning by Blanchard in 1818, the turret lathe by Stone, the automatic screw machine by Spencer, the multispindle lathe by Henn and Hackewessel. We have the broaching process, precision die work, drilling and tapping machinery, and the whole brood that have been brought into being by the automobile industry. Paralleling all this is a century of steady refinement in small-tool equipment and gaging practice which has made these machines effective. What a list, and where would modern industry be without them!

Interchangeable manufacture gives an output better in quality, cheaper in cost, and more useful than would be possible without it. It constitutes one of the greatest contributions of the machine age, and we can be proud that when the British government introduced it into England they called it "the American System."

RUBBER PLATES *and* GRAPHIC ARTS

By J. B. SHAUGHNESSY

RUBBER PRINTING PRODUCTS DIVISION, AMERICAN WRINGER COMPANY, INC., WOONSOCKET, R. I.

MANY YEARS ago, progressive printers realized that letter-press printing had its limitations and set about to make them more elastic. When elasticity entered their minds, rubber immediately followed. They took old offset blankets, glued them to wood blocks, and made tint blocks or engraved simple designs or patterns on them. This was the start of the rubber-printing-plate idea.

This crude form of rubber plate enabled them to obtain effects that had previously been thought impossible. Rubber stamps were then tried to further this end. Unfortunately, inaccuracies in thickness regardless of the care taken by the stamp manufacturers prevented their use. Some of these rubber stamps failed after only a few thousand impressions, because the rubber lacked oil resistance. The rubber plate idea was discarded. At that time, the causes were never investigated or considered, the thought being, and truly enough, that they were "no good."

Then came the rubber water-color age and rubber plates flourished. Beautiful effects were obtained from crude hand-engraved plates in conjunction with water-soluble inks. Large establishments clamored for licenses at a high price to allow them to use a process embodying rubber plates. However, most license arrangements are comparatively short-lived, and the expensive process was dropped. Many were thoroughly disgusted, for they had taken the rubber printing plate intended for water-color inks and endeavored to use this type of rubber compound with oil inks, which deteriorated the rubber and caused plate failure.

RENAISSANCE OF RUBBER PRINTING PLATES

About five years ago the rubber-plate idea again came to the fore. Many rubber companies advertised "oilproof rubber" but the plate buyer, although he knew its applications and uses, was by this time skeptical. However, the rubber companies with their vast resources for chemical research were active by this time and set about perfecting a compound that would resist abrasion and also oxidation by the ingredients in average oil inks and that could be handled by the average plate manufacturer in a vulcanizer as well as by the engraver of simple and crude designs, tint blocks, and similar decorative effects. This idea has progressed and has resulted in improvements, almost day by day. Only five years ago, ten thousand impressions were considered rather fine from the standpoint of plate life, whereas today printers complain of only getting one hundred thousand impressions, and runs of a million and more are not uncommon.

Let us consider this enthusiasm and find the reasons for the interest in rubber plates. Why should anyone want a rubber plate? A metal plate was serving the purpose; and did a real reason exist for making any changes? This, of course, was easily explained because only coated papers were used for the majority of printing jobs and, as a matter of fact, it was the only paper that the average printer knew how to print on and that could be successfully printed in letterpress. When antique finishes, offsets, laids, and other rough stocks were suggested, the printer threw up his hands or tried to "unsell" the customer on their use.

Rubber printing plates are now being manufactured commercially for all classes of work. They have been found to be particularly suitable for use on cover stock, embossed papers of all types, handmade finishes, glassine, cellophane, celluloid, metallic papers, and cloth, glass, tin, and other surfaces that ordinarily cannot be printed from metal plates or where perfect coverage without mottle and the minimum quantity of ink are essentials. Many offset houses having letterpresses are using rubber plates and are selling printing from them that cannot be distinguished from offset by the average printer. Short runs in offset are not practical and are costly.

Any type of ink can be used on these plates. However, those containing chemicals that are rubber solvents are, of course, most harmful as an oilproof plate does not exist. All rubber when it comes in contact with a rubber solvent has a tendency to swell. Swelling gives overimpression and results in plate failure.

RUBBER PRINTING PLATES HAVE MANY AND VARIED APPLICATIONS

Molded rubber printing plates can be made and mounted on various kinds of metal or patent base, curved for rotary presses, or blocked type-high for locking in a chase. The newer type of plate now being used on rotary presses is an adhesive-backed plate. It is mounted on a smooth cylinder or on a saddle that has previously been affixed to the cylinder and can be mounted or removed in less than a minute's time.

Rubber manufacturers have gone far toward making a good rubber compound for manufacturing a printing plate. However, ink companies have not been able, thus far, to perfect an ink that will not affect rubber plates materially. They, of course, are limited to varnishes, all of which affect rubber to a degree, some more than others, the oils in the varnishes having the same origin as the rubber—both vegetable.

Multigraph printing is becoming popular, not only for straight type work but also for line cuts, and Ben Days in two or three colors are being printed successfully from rubber plates. Exceptionally long runs, many over a million, have been reported. Due to elasticity of the rubber, half tones have not been entirely successful. However, newspaper screens and those up to 85-line have been done with fair success. The ordinary 65-line screen when printed from rubber appears to be between 85 and 100 and an 85-line screen takes on the appearance of 120 to 133. This, of course, is only an optical illusion brought about by the impression on the dots which closes them and spreads the dots slightly. Half tones from rubber

Presented at the Graphic Arts Technical Conference, New York, N. Y., May 6–8, 1937, held under the joint auspices of the Graphic Arts Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS and the Graphic Arts Research Bureau.

do not have the values that can be obtained from the metal plate on coated paper but, with stocks on which no printer would attempt to print half tones, a rubber plate can produce a commendable job.

Advertisers in general can effect great savings, due to the fact that one metal key plate can be made and color separation obtained from this plate and an original color drawing. The remainder of the colors are hand-engraved. The metal key plate is, of course, molded into a rubber plate and generally carries the burden of detail. Many effective advertising pieces have been done in this manner with savings of $200 to $300. In general, they are run in conjunction with a campaign and never used again. Therefore, nothing is to be gained by saving the original plates and the rubber plate serves its purpose. It can be used again if stored away from light and heat and can be kept for three or four years if proper care is taken of it.

Printing of a rubber plate requires a certain degree of skill. A kiss impression on the sheet, lightest possible roller setting, and a soft ink are used. Wherever possible, make-ready is accomplished through underlays and, if necessary to put patches under the tympan, they should be buried as deep or as close to the metal as possible.

CARE USED IN MAKING TRANSFER DETERMINES QUALITY OF PLATE

Rubber printing plates are manufactured in several different ways, the original method being hand engraving. As a first step, the rubber is cut to the desired size for the plate, an allowance of 1/4 in. on each side being made for tacking to a block or beveling for patent base.

If the copy is a sketch, a tracing is made on paper that does not stretch or wrinkle. A 3 H pencil is used as this pencil keeps a point and yet deposits enough graphite on the paper to transfer to the rubber. After the tracing has been made, the paper is placed, drawing side down, on the rubber in the proper position and held by a weight so it will not shift. The engraver then rubs the tracing down onto the rubber with a blunt stick or other type of material that is smooth and round and will not have an abrasive or sticking action on the tracing paper. He carefully rubs along each line that is to be used as a guide in cutting the rubber. The paper must not wrinkle or stretch because, for a two- or three-color job, the same tracing is used once for each color which is cut by the engraver on its individual plate, and, if the paper stretched, the plates would not register. Great care must be exercised in this operation, as the success of a plate depends on the proper transfer from the original. Where a metal plate or type is used as copy, it is inked with ordinary printing ink and a proof taken on "glassine" paper and the transfer made from the proof, as it would be from a tracing. Glassine is used because ink will not dry as readily on this paper and no detail is lost, while if ordinary paper is used, the ink strikes into the sheet and part of copy will not transfer. If the artist draws on the rubber direct, he must be careful to draw and letter backward, so that when the plate is used for printing, it will print to read correctly.

A large plate or one having considerable detail presents the hazard of the engraver rubbing or slurring his transfer with his hands while engraving. The best way to avoid this is to spray or brush a thin coat of clear shellac over the entire plate before engraving, and, when the plate is completed, the shellac can be washed off with alcohol. If the transfer is made from a proof, the transfer should be powdered with talc to prevent slurring.

ENGRAVING AND STRIPPING REQUIRE SKILL

The plate is now ready to engrave. The engraver uses a regular "Gillette" knife that is made for this purpose. Special blades are also sold, but the Schick razor blade is superior and holds an edge much longer. It is ground on one end to fit the holder and sharpened with a single bevel, like a wood chisel, at an angle of about 30 deg. The knife is held in the right hand like a pen and is always pushed away from the engraver. In this way, he can always keep the knife on the line along which he is cutting and thus cut the rubber with the proper bevel.

Rubber should always be cut with the bottom of the image wider than the top. If rubber is cut square or undercut, which is the tendency when pulling a knife, the image will not have any support on the edge and will have a feathery appearance when printed. The engraver can always feel the fabric when pushing a knife and he should try to avoid cutting the fabric while engraving. Lines should be cut with a straight edge by pulling the knife toward the engraver, but care must be taken to keep the proper bevel which should be 60 deg and never less than 70 deg. The plate is moved to the knife rather than the knife to the plate.

No stripping is done until the entire plate has been engraved. This is most important because the rubber on the plate supports itself and keeps the lines accurate and prevents stretch of the rubber at the time of cutting. After the entire plate has been engraved, the engraver takes his knife and cuts down through the fabric to the metal in the large areas to be removed and removes the rubber from the metal with his fine-pointed pliers, a pair of so-called alligator or long-nosed pliers ground on the end being most suitable for stripping. When all the large areas have been stripped, he takes his tweezers, which also have fine points, and carefully removes the top layer of rubber only alongside of each image or character; the fabric and second layer of rubber give additional support and better adhesion to the lead backing. Care in stripping is most important, since if a small line should not be cut, part of the plate might be torn and not easily repaired. A good engraver strips with his tweezers and knife at the same time, always using the latter to relieve the rubber while pulling it away.

FINAL STEPS IN PRODUCING PLATE

The plate is then cleaned up in the background and trimmed for use. If the plate is to be mounted on a patent base, it is beveled on all sides. For blocking type-high, the edges and perhaps a spot or two in the center are drilled with small holes and tacks put in. Care must be taken here since the lead backing is soft and if tacks are driven through it without first drilling, the lead might spread and cause a high spot on the plate, or if the tacks are driven through the lead they will produce low spots at these points, and excessive squeeze or impression will be required to bring them up, thus causing the plate to wear out before it should.

Washing off the shellac with alcohol is the final step, and the plate is ready for use. No rubber solvent, such as kerosene or gasoline, should be used for a plate wash. Naphtha or benzene are used sparingly at times, but they also damage the plate, although evaporating before they can do much harm. The danger is that the solvents will attack the cement that holds the plate to the backing and that some small character would be softened and might fall off. Printing of the plate is comparatively simple. If make-ready is necessary, it should be placed under the plate and not under the tympan, and if the latter is necessary, the underlays should be located as deep or close to the metal as possible. The ink should be butter soft, not soup, as rubber plates will take the ink and lay it much more easily than metal plates.

Roller setting is a more important item. Form rollers should not sock the plate, as this kind of setting will ruin it. They

should be set to kiss or bear as lightly as possible. Likewise the impression on the sheet should be a kiss, as excessive pressure on the plate will tend to distort the images so that second and third colors will not register; also the rubber will wear and pit wherever the impression is too great. Hard packing is always desirable.

ADDITIONAL PLATES ARE REPRODUCED CHEAPLY AND QUICKLY

Molded rubber printing plates are made in a vulcanizer from an original metal master. Reproducing the rubber plates, under these conditions, is comparatively simple and practically a mechanical operation. The mold or matrix is produced from type, cuts, or electrotypes, and as many plates as are required can be reproduced from each mold. Generally a phenolic compound, one form of which is known as "bakelite," is used as matrix material, although many are on the market. This material must be molded at a temperature of approximately 300 F, and is allowed to remain under that heat and with sufficient pressure to give the mold a uniform thickness for eight to ten minutes. The mold is then removed from the master and is ready for producing the rubber plates. These plates are made to any required thickness and with any type of backing such as lead, aluminum, or brass; spring brass for multigraph use, or nonbacked for aniline printing machines.

The cost of molded rubber plates varies from $1/2$ to 2 cents per sq in., depending on how they are ganged on the press platen and the number produced in a working day. Many printers are today manufacturing their own rubber plates at a cost far below that of electrotypes or stereotypes, and they are getting results that are in a class by themselves.

Decided interest has been displayed in the use of synthetic rubber and resins to replace rubber. Most of these materials are cold-flow and are highly oil-resistant. Unfortunately, inasmuch as they are cold-flow materials, their resistance to abrasion is comparatively low, and, although they do not oxidize as readily as rubber, they wear or slough away with a result that their life is shorter.

A new method of treating a rubber plate today, known as case hardening, lengthens its life six to eight times. A good example of this is printing on chip board with a steel-faced electro that averaged 90,000 to 100,000 impressions before the plate was no longer fit for use. The printer decided to use an ordinary rubber plate for the same job and averaged 20,000 to 25,000 impressions. He later tried a case-hardened rubber plate and ran 240,000 impressions before the plate was no longer fit for use. Therefore, the rubber plate apparently gave much better service and had a longer life than a metal one. This, however, in our opinion, is not entirely true, as the stock on which he was printing was highly abrasive. It bears out one point which, in our estimation, is most important, a rubber plate used in the proper place is the best medium for the transfer of ink to paper.

Another point to be borne in mind in regard to molded rubber printing plates is that the initial installation for manufacturing this type of plate is low in cost, and $2500 would cover the machinery necessary for a fair-sized printing establishment. To assume that with low-cost equipment, overhead and production cost would be in proportion is only natural. Further, from a service standpoint, a complete rubber plate, ready for use, can be produced in from twenty minutes to a half hour. This fact is of untold value to the printing establishment when a plate is damaged and a new one is necessary, because, in all probability, the printer already has the mold and can complete a replacement plate in ten minutes, thus eliminating waiting time for the press and speeding up production materially.

A newer type of printing is coming into vogue, or let us say that an old type is becoming popular, which is known as aniline printing. This is becoming popular in the paper-box, bread-wrap, candy-wrap, and gift-wrap fields. Finishes were available, most of which did not lend themslves to good letterpress printing. Fancy finishes, mostly embossed, were not suitable, or were too expensive, for average jobs that could use a decorated or fancy finished paper. The total tonnage sold to converters for printing by intaglio, coating, frictioning, or flinting was not as large as two mills' direct sales to large paper users today in fields that had not been touched in the past. Demand for papers with designs, trade-marks, and decorations in the box, papeteries, fancy-finish, offset, wrapper, and greeting-card fields was heavy. Quality-paper manufacturers were beginning to find a demand in the market for papers having a good appearance which would cost less and yet be effective.

ANILINE PRINTING AND STAINING

They investigated the aniline printing and staining field. In the first place, only machines of foreign manufacture were available and paper manufacturers were skeptical because they knew nothing about them and were under the impression that the machines were complicated, but this idea was soon dissipated. Next, they learned that aniline inks were fugitive and, therefore, limited in use to papers that would not come in contact with direct sunlight; however, they could use them on some types of work. The next question that arose concerned printing rolls which had to be purchased in foreign countries and required two to four months for delivery so that only those who planned far in advance could hope to use them. Manufacturers had visions of their machines, if installed, being idle a great part of the time on account of lack of promptness in design-roll delivery.

Most industries have pioneers. Likewise, in the paper industry, one or two of the braver members ventured forth and purchased aniline printing machines to see what could be done. They were endeavoring to bolster up a steadily declining market that lacked something new and different. After a time, they called on ink companies and dyestuff manufacturers to do something about the ink. This has been done, not entirely, but to a point where no one fears an aniline ink or that it will be fugitive. The ink is no longer a true aniline, but is now just a fluid ink. It is still waterlike but uses pigmented aniline dyestuff and, in some instances, a lacquer. Ink was only part of the difficulty. Mills were getting inquiries and an occasional order that stipulated three weeks' and one month's delivery of paper that was done in a specific design. Therefore, they cast about for a rubber design-roll manufacturer. There was no such thing! Why should there be? There was no demand! Several companies tried to make rolls, and many were produced but none were as good as the foreign rolls. Accuracy and fineness of detail were not apparent. Proper technique was lacking.

SOME POSSIBILITIES OF RUBBER PRINTING PLATES

Today, one domestic-roll manufacturer is completely equipped with knowledge, experience, and equipment to manufacture rubber printing or design rolls that will outlast and be more accurate than those of foreign manufacture. In many instances, complete rubber rolls, ready for use, are shipped within three days from receipt of an order, while three and four years ago, shipment required four weeks. On one occasion, where a paper mill was required to promise delivery of the first paper within a week, the complete trade-mark rubber design roll was shipped to the mill 48 hours after receipt of the roll order.

A textile manufacturer can, therefore, change a brand, order his wrapping paper, and ship goods in the same season. A shoe

manufacturer might redesign his name or trade-mark and have boxes covered with the new design within from three to four weeks. Greeting-card manufacturers can include last-minute designs in current lines. Likewise, no long conferences and large appropriations are necessary for users of wrapping papers to trade-mark their papers; the cost is nominal and the advertising value, great. Corrugated-box manufacturers are printing over-all patterns or designs on the board as it comes from the combiners and then overprinting the name and quantity of the specific item that goes into the container. Several liquor manufacturers are now purchasing boxes which are done in this same manner.

Paper can be watermarked with rubber design rolls and an ink that penetrates the sheet and makes it more transparent in the mark, without disturbing the fibers in the sheet, and at a fraction of the cost of a dandy roll. Perhaps, many will criticize the method or idea, but, if it is not done in this manner, it never will be, and the additional revenue will never be collected.

Staining papers with rubber rolls and fluid inks is also an important feature. Small runs of tissue or lightweight papers can be done, and done well, on an aniline machine. One manufacturer, who has as many as 30 shades of tissue to do on short notice, saves money by running white and unbleached stock and staining for color shades. He runs the exact quantity of paper required and cuts out the staining machine or switches to another color. Another mill runs a two-toned sheet with a fluid ink and it appears to be coated when completed.

The field of rubber design rolls in this new and versatile machine, employing fluid-type inks, has only been scratched. With slight changes, unlimited effects and uses can be accomplished. These machines are being speeded up to the point where 800 to 1000 fpm is not far off. Drying is almost instantaneous and no festooning is necessary; neither is the printability of the paper affected. Inks can be changed to meet the requirements as to opacity, drying, brilliance, and the like. Precision rubber printing and design rolls are here.

Another new thought in connection with printing has been the combination of aniline and letterpress printing in the same operation. This work, of course, is done from web, the idea being that use of oil inks on large solids is expensive. Furthermore, drying becomes an all-important problem but is easily solved by using anilines for one or two colors in the large solids and oil inks for fine details since aniline inks dry instantaneously and do not affect the subsequent printing of oil inks. One printing-press builder has already made the plans for a six-color press of this type. Often, a job requires a particular shade or color of paper, and buying a particular quantity of paper from the mill in a beater-stained sheet is not practical. With a press of this type, the exact quantity of paper can be stained to the desired shade and printed in the same operation. Weeks of waiting for paper deliveries are thus saved. Service to the customer could not be better. One English company has been satisfied to use the process in its own plant for some time and say nothing about it to the world. I have seen some work done by this firm which was beyond criticism. The application and use of rubber plates have barely been explored, and, henceforth, rubber plates apparently will be adapted to jobs that heretofore would never have been considered.

H. Armstrong Roberts

DYNAMIC PROPERTIES *of Structures* DETERMINED *by* MODELS

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DETERMINING the dynamic properties of engineering structures in a purely mathematical way (1–5)[1] is often difficult and in certain cases almost impossible. As soon as any structure becomes sufficiently involved by the addition of various single members or whenever unsymmetrical loads are applied, mathematical difficulties increase rapidly, and it becomes necessary to consider a more simple method. A truss bridge having several continuous spans of different lengths is an example of a structure whose dynamic properties should be predetermined. This is especially desirable in studying the influence of moving loads, the most important of which occur when unbalanced locomotive drivers pass over the span.

In this case the theoretical solution of the problem becomes difficult. Hence this paper deals with the possibility of using models for determining the dynamic properties of complex engineering systems. The question comes up, what kind of similarity equations must be used to tie up the behavior of the model with the actual structure. This paper endeavors to avoid any complex mathematical and dynamic equations to enable every engineer not familiar with these questions to follow the development.

FUNDAMENTAL PRINCIPLE

The most important dynamic properties are natural frequency and damping capacity of an oscillating system. The latter effect depends on the rigidity or internal and external friction of the structure, i.e., friction of the support, air resistance, damping in the material, and the like. The amount of damping determines the size of the amplitudes and hence the stress in the vibrating system. The fact must be kept in mind, however, that almost every engineering structure has a small damping capacity. For buildings and vehicles the logarithmic damping decrement varies between 0.1 and unity. Furthermore, it is a well-known fact that natural frequencies and resonance almost coincide for small damping capacities. In other words, if damping effect is neglected, the natural frequency of an engineering structure can be determined accurately enough by comparison with a model. It should be understood that the damping capacity of the model must also be small. Determination of the natural frequency is of considerable value in cases where resonance with periodic exciting forces, i.e., revolving machine parts, must be avoided.

In general, three similarity equations must be discussed. They are similarity of geometric proportions, of time, and of forces. For reasons of simplicity, the model is assumed to be made of the same material and to have the same modulus of elasticity as the actual structure, thus partly eliminating the force and time relation.

Let m equal a linear dimension, length, breadth, or thickness, of the actual structure, and m_1 equal a corresponding dimension of the model, then the following equation is valid:

$$m = (1/x)\, m_1 \quad \ldots\ldots [1]$$

[1] Numbers in parentheses refer to Bibliography at end of article.

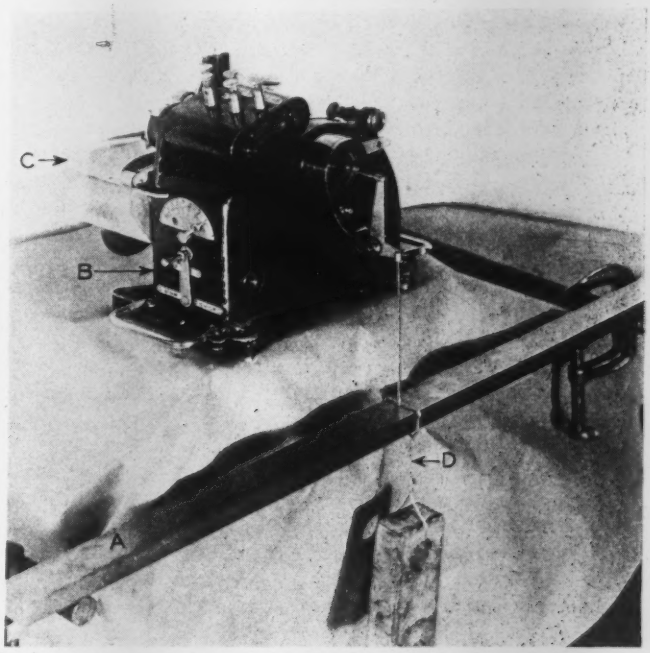

FIG. 1 DETERMINING NATURAL FREQUENCY OF A STEEL-BAR MODEL WITH DEFLECTOMETER

(In the illustration, *A* is the steel bar which rests on two supports; *B* is the deflectometer housing; *C* is the chart on which the vibrations are recorded; and *D* is the string that, when cut, releases the model for free vibration.)

where x is the scale reduction of such geometric proportions. If we consider a simple girder on two supports, the deflection d of the girder is a function of the deadweight P, the cube of the span length l^3, and the moment of inertia I, or

$$d = \text{const} \times f\,(Pl^3/I) \quad \ldots\ldots [2]$$

The natural frequency ω is a function which is approximately the reciprocal of the square root of the deflection, or

$$\omega = \text{const} \times f\,\sqrt{1/d} \quad \ldots\ldots [3]$$

or Equation [2] combined with Equation [3] gives

$$\omega = \text{const} \times f\,(I/Pl^3) \quad \ldots\ldots [4]$$

I increases with the l^4, the fourth power of the geometric dimension, and P increases with l^3, the cube. Hence

$$\omega = \text{const} \times f\,\sqrt{l^4/l^6} = \text{const} \times f\,(1/l) \quad \ldots\ldots [5]$$

or

$$\omega = (1/x)\,\omega_1 \quad \ldots\ldots [6]$$

Equation [6] means that the natural frequency of the model is

x times as high as that of the actual structure, always keeping in mind the original assumptions.

VERIFICATION OF RESULTS BY TESTS

To verify this result various tests have been made. Two steel bars having dimensions of 20 × 2 × 1 in. and 10 × 1 × 0.5 in., respectively, were supported at their ends on rollers (Fig. 1). Corresponding Equation [1] is $m = 2\ m_1$. The natural frequency was determined as follows: A heavy weight was hung by a string in the center of the bars and was cut with a flame, thus releasing the bars suddenly. Free vibrations of the two bars were registered by a deflectometer, which thus recorded the natural frequency of the bars under their own weight. In this particular case the deflectometer was a modified Geiger vibrograph, with a natural frequency which was sufficiently high as not to interfere with the frequency to be indicated. The vibrating mass had been removed and a simple reducing lever transmitted the oscillation of the specimen to the recording pen on a chart. The paper was driven by a mechanical clockwork and the timing was done by the usual tuning fork, recording continuously 50 cycles per sec. The natural frequency of the larger bar was determined to be $\omega = 202$ cycles per sec and that of the smaller bar to be $\omega_1 = 407$ cycles per sec. Corresponding Equation [6] is $\omega = 1/2 \times 407 = 203.5$, which shows an error of 0.75 per cent.

When using more complicated models, the natural frequency can be determined by vibrations excited by a so-called "oscillator" (6) (Fig. 2). It consists of two revolving masses eccentrically supported and rotating in opposite direction (Fig. 3). All horizontal forces being neutralized, vertical forces of a pure sine form remain. The wave length of this sine form depends on the frequency of the rotating disks, i.e., speed of the driving motor and the amplitudes of the eccentricity of the two masses.

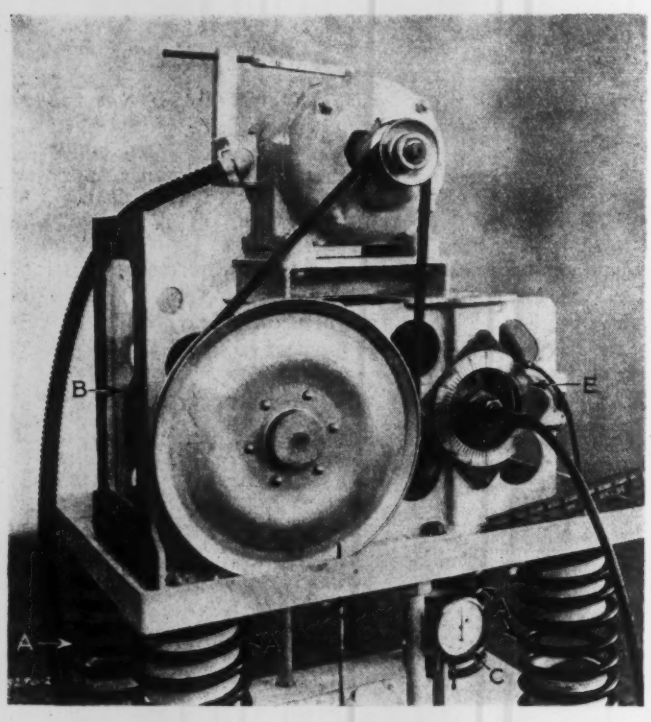

FIG. 2 DETERMINING NATURAL FREQUENCY OF FOUR SPRINGS WITH AN OSCILLATOR

(The springs are indicated by *A*; *B* is the oscillator; *C* is the deflectometer; and *E* is the phasemeter.)

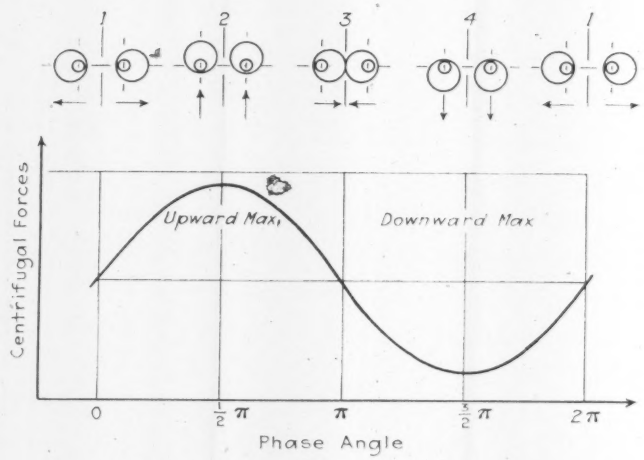

FIG. 3 OPERATING PRINCIPLE OF THE OSCILLATOR SHOWN IN FIG. 2

(The position of the rotating masses during one revolution is shown in the upper part of the illustration and the alternation of the centrifugal forces in a true sine curve is shown beneath.)

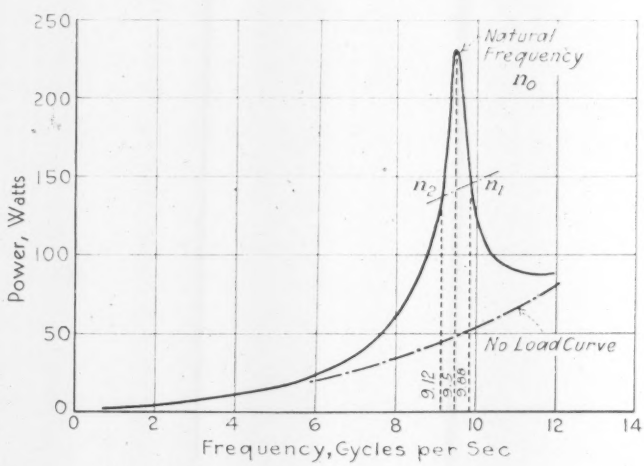

FIG. 4 POWER-FREQUENCY CURVE OBTAINED FROM THE MODEL TEST SHOWN IN FIG. 6

(The natural frequency $n_0 = 9.5$ cycles per sec. Damping angle $\tan \varphi = (n_1 - n_2)/n_0 = (9.88 - 9.12)/9.5 = 0.08$.)

Plotting frequency of the masses against the power input of the driving motor, a so-called power-frequency (7) curve is obtained. (See Fig. 4.) For small damping capacities, the peak of this curve indicates the natural frequency, thus forming another simple means of determining free vibration of any model.

In laboratory tests on models, such as bars, rods, axles, crankshafts, springs, or riveted and welded joints, a cantilever arrangement (Fig. 5) or a simple truss or girder (Fig. 7) can be used. The desired initial load can be applied by a special loading platform, simulating the dead load. These systems have been in use for several years in material-testing laboratories in Europe (8).

With standard stress or deflection-measuring instruments attached to the specimen to be tested, exciting forces of the oscillator can be controlled. In special cases, the structural value of riveted or welded girders of various steels or alloys or of concrete can be compared simultaneously with one oscillator (Fig. 6). By plotting power-frequency curves during the endurance test, certain changes in dynamic properties of different

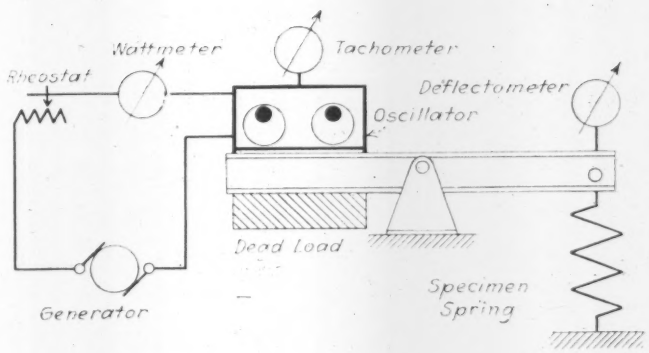

FIG. 5 OSCILLATOR ARRANGEMENT FOR DIRECT-STRESS TESTS

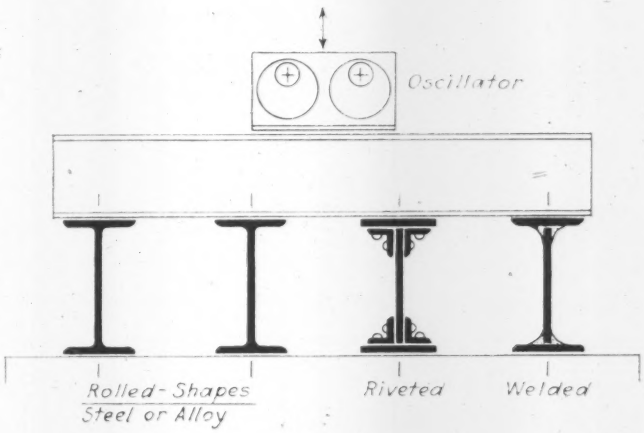

FIG. 6 COMPARING THE STRUCTURAL VALUES OF VARIOUS STRUCTURES SIMULTANEOUSLY WITH AN OSCILLATOR

materials or structures can be followed. Temperature measurements with thermocouples distributed over the model may indicate a weak spot, where the first failure or plastic flow may occur. The fact must be borne in mind, however, that the deadweight of the oscillator must be considered when comparing the model with the actual structure.

Unsymmetrical loading can be easily imitated. By shifting the oscillator to any desired loading point on the model, vertical, horizontal, or torsional oscillations can be excited. To predetermine these effects theoretically, especially when they superimpose on one another, is rather difficult.

The possiblity of imitating the damping effect by a model cannot yet be decided. The width of the previously mentioned power-frequency curve indicates the damping capacity (8) (Fig. 4). Further tests are under way in an investigation of this special question.

NUMERICAL EXAMPLE

The calculations for the test with the two steel bars described above are as follows:

Modulus of elasticity $E = 30{,}000{,}000$

Specific weight of steel = 0.283 lb per cu in.

Loads are $P = 11.32$ lb and $P_1 = 1.415$ lb

Moments of inertia are $I = 0.164$ in.^{4} and $I_1 = 0.01041$ in.^{4}

Deflections are $d = (5/384)\ Pl^3/EI = 0.000236$ in. and $d_1 = 0.000059$ in.

Frequencies are $\omega = \sqrt{9.84/d} = 204$ cycles per sec and $\omega_1 = 410$ cycles per sec.

Corresponding Equations [6] are $\omega = 1/2 \times 410 = 205$ cycles per sec which shows an error of only 0.5 per cent and checks with a deviation of approximately 1 per cent from the test results.

CONCLUSIONS

(1) It is almost impossible to attempt to calculate theoretically the dynamic qualities of complicated engineering structures, especially when unsymmetrical loads or the superimposing effects of vertical, horizontal, and torsional vibration come under consideration.

(2) Model tests can easily be made to determine experimentally the natural frequencies of any engineering structure, making use of the proper similarity equations. This may be important to avoid a coincidence between the natural and any other frequency of the exciting forces.

(3) The question of the possibility of predicting the damping capacity by a similar method still remains open. Further tests are under way.

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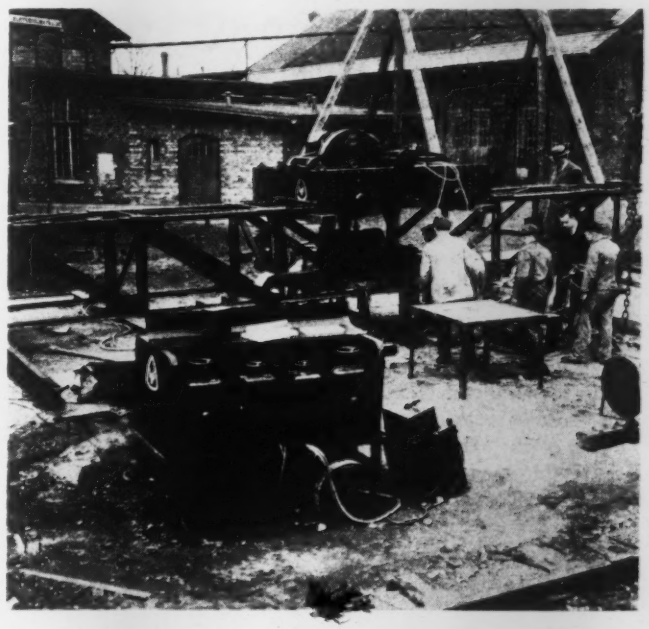


FIG. 7 DETERMINING NATURAL FREQUENCY AND DAMPING EFFECT OF A TRUSS MODEL WITH OSCILLATOR

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While few quotation marks are used, passages that are directly quoted are obvious from the context, and credit to original sources is given.

Day by Day

GLEANINGS from the news of the past month of items that catch the eye of the engineer show transportation still in the lead for popular interest, aviation, the merchant marine, and the railroads forcing themselves well up to the top of the list. Summer is the season of great activity in aviation, and the youth of the industry provides not only ample opportunity for novelty, but a constant pressure on those connected with it to place the record of its progress before the public. In the more prosaic fields of the merchant marine and the railroads we are witnessing the characteristic secondary growth acceleration which is generally induced by competition and stimulates improvements and public interest.

VINDICATED

It is gratifying to discover from the report of the Department of Commerce board that investigated the accident on August 2, near Cristobal, Canal Zone, resulting in the destruction of the plane of the Pan American-Grace Airways, Inc., that no fault attaches to the pilot, Stephen Dunn. According to the report, failure of one or both engines, resulting from faulty gasoline system, was the most probable contributing cause of the accident. Because of storms, Pilot Dunn apparently decided to go out over the Carribean in order to get down through the overcast, rather than run the risk of coming down over the Isthmus with its hazardous hills and radio towers. In the opinion of the board, this judgment was excellent. The board was further of the opinion that, after spiraling down, the ship struck the water at a speed of not less than 90 mph and was torn to pieces, resulting in the death of the 14 on board. Evidence of fire found on the wreckage is attributed to the 80 gal of gasoline which could have burned on the water a sufficient length of time to have charred the wreckage, thus eliminating the probability of fire before impact.

LOST

On August 14 it was reported that the four-motor Russian transport plane was overdue at Fairbanks, Alaska, on a flight from Moscow over the North Pole. Although optimism over the fate of the pilot and his five companions was expressed, to date, in spite of searching parties and elaborate rescue plans on two continents, no word of the whereabouts of the fliers has been received. In a dispatch to the *New York Times*, Moscow, August 14, Harold Denny reported that a clogged oil line was believed to have stopped one engine, forcing the plane to descend to an altitude where icing became a hazard. The plane had covered the 1600 miles from Moscow to the North Pole in 19 hr, 22 min, having met 100-mph head winds.

HELIUM

Under authority of an act of Congress, the United States Department of State announced on September 3 the rules under which helium may be exported from this country. The act declares helium to be a mineral resource pertaining to national defense and authorizes a virtual government monopoly, export to be only under license by the Secretary of State. The rules provide two classes of licenses: (1) For medical, scientific, and commercial use other than aeronautical, and (2) for aeronautical operations. Export license under the first class may be issued for quantities up to 500,000 cu ft to any one foreign country but no more than 20,000 cu ft to one consignee. Reasonable safeguards against unnecessary waste are required. Licenses for export for commercial or aircraft operations may be issued in such amounts as the National Munitions Board and the Secretary of the Interior may deem not sufficient for military use.

In this connection interest attaches to the report from Friedrichshafen that the dirigible LZ130, undergoing extensive reconstruction to convert it to the use of helium lifting gas, will be ready for service next April.

GLIDERS

It has been reported that a Hamburg aviator, Herr Huth, covered the distance of 475 miles from Wasserkuppe to Berlin and back by glider. Several stops were made en route. From Elmira, N. Y., came word that Richard C. du Pont, of Wilmington, Del., has been chosen first president of the Elmira Area Soaring Corporation, an organization that will seek to obtain an international glider meet and discuss plans for establishing a glider school.

"NORDMEER"

The German transatlantic survey plane *Nordmeer*, en route from Luebeck, Germany, via Lisbon and the Azores, landed at Port Washington, Long Island, on Monday, August 16, after a flight of 2392 miles in 16 hr, 28 min, average speed 140 mph, during the last lap from Horta. The approximate distance from Leubeck to Port Washington is 5000 miles. The *Nordmeer* does not take to the air from the surface of the water or from the land but is launched by catapult from a depot ship. The catapult ship *Schwabenland* followed the *Nordmeer* to this country to put the plane into the air for her return journey.

CLIPPER

Shortly after the arrival at Port Washington of the *Nordmeer*, the *Bermuda Clipper* left on a survey flight to Europe via Bermuda and Azores. Arrival at Lisbon was reported on August 21.

IMPERIAL AIRWAYS

Throughout the summer survey flights of the *Caledonia* and *Cambria* have been made with reassuring success. These 3000-hp planes have been able to forecast from weather reports their probable positions during flight and have checked them by wireless with surprising accuracy.

It has been announced that the Imperial Airways and the

British Air Ministry are about to undertake a program of tests of the aerial launching of long-range craft by the Short-Mayo composite apparatus. The two components of this composite apparatus—a large flying boat and a smaller type of long-range seaplane—will first be tested separately. Then the seaplane will be attached to the upper wing of the flying boat and the two craft will ascend under their own power as one machine. After a suitable altitude has been attained the seaplane will be launched in mid-air from its mother craft. See MECHANICAL ENGINEERING, May, 1936, page 304, for an illustration and description of a composite craft.

TRANS-HIMALAYA

Luft Hansa reported from Berlin that its JU52 Danoy *Rudolph von Thuna*, made the first flight over the Pamir Mountains, northeastern range of the Himalayas, in surveying a new route to the Pacific. The route: Berlin, Island of Rhodes, Damascus, Baghdad; Teheran (Iran), Kabul (Afghanistan), Kansu province (China), Soochow, Canton, and Hong Kong. September 8 Berlin reported that in a return flight from Anshi to Kabul over the mountains, the plane was unreported. Search is being made.

RACES

The 1937 Bendix Derby, from Burbank Airport, Los Angeles, to the eastern seaboard (Floyd Bennett Field, Brooklyn, N. Y.) was won by Frank W. Fuller, Jr., in 9 hr, 44 min, and 43 sec, a transcontinental record for the race. From Los Angeles to Kansas City Fuller flew at 16,000 ft, averaging 300 mph (using oxygen at high altitudes), from Kansas City to Cleveland at 7000 ft, and from Cleveland at about 8000 ft.

At the National Air Races, Cleveland, Rudy A. Kling, of Lemont, Ill., won the Louis W. Greve trophy, 20 laps of a 5-mile course, at an average speed of 232.2 mph. The next day he won the Thompson trophy in a 200-mile race at an average speed of 256.9 mph.

DREADNOUGHT

August 7 Sikorsky announced certain details of the Navy's new powerful bomber XPBS that has been under construction for more than two years. The XPBS is a four-engine, all-metal, high-wing, full-cantilever monoplane, powered with Pratt and Whitney 1050-hp twin Wasp engines and equipped with constant-speed propellers. Its weight exceeds that of previous Sikorsky flying boats by some five or six tons. On August 14 the *New York Times* reported that the new ship had made four successful flights. It is said to have attained a speed of 200 mph and to have lifted into the air from the water within a distance of 100 yards.

TARGET

It is reported that the robot plane *Queen Bee* flying at an altitude of 4500 ft, was brought down by the crew of a 16-lb battery in training at Watchet, Somerset, England, with the second shot. The shell is said to have burst a few feet above the *Queen Bee*.

TESTED

At Buffalo, N. Y., Sept. 1, the new multiseater Army plane XFM-1, mentioned in this column last month, was reported to have passed its first flight test.

PROPELLER

A new three-bladed propeller for aircraft was announced by the Curtiss-Wright Airplane Co., Buffalo, N. Y. The blades are of hollow steel and are mechanically controlled as to pitch up to 90 deg, at which position they are said to act as a brake, by means of an electric motor.

MERCHANT MARINE

Joseph P. Kennedy, who was so generously applauded for his realistic launching of the S.E.C., has been getting the Maritime Commission, of which he is chairman, into the news. On August 10 he announced appointment of a special committee of experts to make a survey of conditions in the merchant-marine field and to analyze the Ship Subsidy Act. On the committee serves H. L. Seward, of Yale University, member, A.S.M.E. Items to be covered in the survey include foreign trade, national defense, labor, capital, requirements of the United States, policy of the United States, and costs.

In Washington, on August 16, before the Subcommittee of the House Appropriations Committee, Mr. Kennedy gave a detailed analysis of the Commission's 95-ship replacement program. This showed a total estimated deadweight tonnage of 835,000 tons, and a total estimated cost of $256,440,000. Under title V of the Ship Subsidy Act (ships for government account) the total cost (operator's share 25 per cent, Commission's share 75 per cent) is $109,760,000. Under title VII (private account) the cost is $146,680,000.

Mr. Kennedy presented four points on the general position of American shipping to justify immediate steps to inaugurate the replacement program of the Commission:

1 American bottoms carry only 7 per cent of the world's tonnage in international trade although our share of that trade is 14 per cent.

2 Less than 35 per cent of our own foreign commerce is confined to our own ships.

3 The United States is third in world tonnage (mostly obsolete), fifth in speed of ships, and eighth in rank of modern ships in operation.

4 On June 30, 1936, this country had only 442 vessels of approximately 2,790,000 tons (exclusive of tankers and Great Lakes vessels) in international trade; Great Britain 2129 ships, 13,209,000 tons; Japan 602 ships, 3,025,000 tons; and Germany 463 ships, 2,747,000 tons.

On August 30 Mr. Kennedy announced that safety standards recommended by special Senate Committee on Safety at Sea will be required by all vessels built under the Ship Subsidy Act. He estimated the Commission's total resources for ship-subsidy program at between $340,000,000 and $350,000,000, of which less than one third is in cash. The remainder represents amounts authorized by the last Congress and various receivables, including construction loans and ship-sale mortgage notes.

The proposed regulations include:

1 All vessels must qualify for certificate issued by American Bureau of Shipping evidencing highest ratings or classifications in all particulars.

2 They must have fuel and feedwater provisions for a cruising radius of 6000 miles at sustained speed.

3 They must be built so as to be suitable for installation of miscellaneous protection devices and decks must be stiffened for mounting of such guns as may be specified by the Navy Department.

4 They must conform to all laws and requirements of Bureau of Marine Inspection and Navigation, the Department of Commerce, Navy Department, and U. S. Public Health Service, and to similar laws of foreign countries at whose ports they will call.

5 They must have satisfactory quarters for crew, according to standards now being developed by the Commission.

Engineering and industrial interest naturally attaches to

these notes regarding the program of the Maritime Commission because of the design features involved and the amount of money to be expended in the 95-ship program.

APPOINTMENTS

As a result of a compromise solution to the vexing problem of appointing a successor to Joseph B. Weaver, resigned, as head of the Bureau of Marine Inspection and Navigation, Commander R. S. Field, U. S. Navy, was named on August 25 to that position by Secretary of Commerce Roper.

Secretary Roper also announced, on September 7, that H. L. Seward, of Yale University, member, A.S.M.E., had been appointed his special adviser on shipping. Professor Seward's position will provide for general supervision over the department's marine activities, and also establish liaison contact between the department and other government agencies which deal with marine affairs and of which there are said to be about twenty.

RAILROADS

The new B. & O. locomotive, the *George H. Emerson*, is reported to have recently attained a speed of 90 mph. The locomotive has four cylinders arranged for single expansion. They are mounted in pairs at either end of the engine, each pair connected to four pairs of drivers. The locomotive is named for Col. George H. Emerson, chief of motive power and equipment, Baltimore & Ohio Railroad, a member of the A.S.M.E.

The New York Central put into service the first of 50 new Hudson-type locomotives. All main and side rods are of alloy steel, and there are roller bearings on all axles as well as main- and driving-rod ends. The larger boiler generates steam at 275 lb per sq in.

A United Press dispatch from Paris stated that on August 31 the Popular Front Government took over control of railroads in France to make the six large private systems, with two others already under state control, a network for mobilizing the entire army, including 6,000,000 reserves, in 48 hours. The government will hold 51 per cent of the new capitalization. The new government company will not function until Jan. 1, 1938.

Addressing the Association of Railroad and Utility Commissioners, Carroll Miller, chairman of the Interstate Commerce Commission, proposed that all railroads be operated as one national system. He made it clear that "the Commission is in no way responsible for what I may say," and was not specific as to the character of the ownership under his proposal.

RESEARCH

On August 11, the Association of American Railroads announced that it had established a Division of Engineering Research to expand and coordinate research work now being carried on by the railroads of this country in so far as it affects the physical properties. The new division will absorb the work now being done by the Division of Equipment Research. L. W. Wallace, member, A.S.M.E., who has been head of the Equipment Research Division, has been appointed director of the Division of Engineering Research. G. M. Magee has been appointed assistant director.

COTTON

The AAA announced on August 29 that an additional allotment of $100,000 has been made for continuation of work in developing and expanding new uses of cotton. Surplus cotton to the extent of 8500 bales had previously been made available for experimental use of cotton fabric in highway construction and $7000 was authorized for work toward development of other uses in March, 1937.

The new allotment will also furnish cotton for work on several proposed new cotton uses: Fabric for windbreaks to control soil blowing, reinforcement for asphalt-lined irrigation canals, reinforcing material for coverings on levees and revetments, as covering on protective material on banks of dams and reservoirs, as protective covering in seeding lawns and terraces, as covering for enclosures for propagation of insect parasites, as covering to prevent escape of insects from storage plants and other sources of infestation, to prevent or lessen nuisance caused by winged wild life, and as covering for cotton bales.

Cotton and cotton products for these investigations will be furnished to federal, state, and local governments and to colleges and other nonprofit organizations. The program is sponsored by the marketing section of the AAA.

COOLEY

From the *Michigan Alumnus* of Aug. 14, 1937, it is learned that a proposal has been made to set up a Mortimer E. Cooley Foundation at the University of Michigan in honor of Dean-Emeritus Cooley. Dean Cooley is a past-president and honorary member of The American Society of Mechanical Engineers and one of a famous group of Navy men who entered the field of engineering education during the latter part of the last century. It is proposed that a fund of five million dollars be raised to provide money to supplement state support for the financing of salaries of eminent teachers and for facilities and equipment needed. It is hoped that the Foundation will also make possible the granting of scholarships and fellowships.

TAYLOR

Announcement of the proposed Taylor Model Ship Basin, to be built for the Navy Department at Carderok, Md., appeared in the *New York Herald Tribune*, August 8. The proposed basin, to be used by both the Navy and private steamship and shipbuilding companies for experiments in hydrodynamics leading to predictions of power and speed, maneuverability, and riding qualities of ships, is to be named in honor of Rear-Admiral David Watson Taylor, U.S.N. retired, John Fritz medalist, a pioneer in the use of model ship basins in securing construction and design data.

From the preliminary description it appears that three basins are contemplated, a wide basin for work with models of large vessels, a shallow basin for studies of river-craft models, and a long high-speed basin for testing seaplane pontoons and high-speed liners. It is said that there will also be a turning basin for steering tests. One of the basins will be 1600 by 20 ft with a 10-ft depth; another 690 by 50 ft with a 22-ft depth; and a third 200 ft long, or 300 ft with a turning basin 50 ft wide and 10 ft deep. The basin structure will also house a laboratory for testing ship structures and a storeroom for models.

Another Taylor (Frederick Winslow), a former president of The American Society of Mechanical Engineers, was mentioned in the news from Germany in a dispatch to the *New York Times* commenting upon industrial and economic conditions. Among reserves in resources to which the Nazi government may resort, the correspondent mentioned a nation-wide campaign to rationalize industry "to convert hitherto extensive use of labor into intensive use and thereby increase production per capita." It is said that this is to be done by extending the working day, but mostly by increasing efficiency through what is called the "Taylor system with social justice." The correspondent goes on to say that methods of increasing labor efficiency are now being worked out by the Labor Scientific Institute of the German Labor Front, and that, pending completion of its work, the campaign is being conducted under the idea that better condi-

tions of work and "an efficiency wage rather than a boom wage" will produce immediate results.

SCIENCE

In England the British Association for the Advancement of Science and in the United States the American Chemical Society have been meeting with filtrations into the press of their deliberations. At Nottingham, England, Irving Langmuir, A.S.M.E. Holley medalist in 1934, reported extension of his method to the study of monomolecular layers of proteins, opening, it is said, new fields of research in biology and medicine. The organic chemist, he is reported to have said, has gone as far as he can, so that the physicist and geometer must step in to provide a clear understanding of the nature of living processes and general constitution of organic matter.

At Rochester, N. Y., a variety of subject matter claimed attention. Dr. Harold C. Urey reported a distinctly chemical method by which 0.2 gram of heavy nitrogen can be produced every 24 hr, thus providing quantities sufficiently large for research uses. Dr. Urey and his coworkers are said to have used a countercurrent scrubbing apparatus of the distillation-column type originally designed by George B. Pegram, member A.S.M.E.

A paper on coal hydrogenation, indicating that 84 per cent of a ton of coal can be made into oils, and an announcement of the discovery of a method of making trinitrotoluene from petroleum instead of coal, aroused popular interest.

SKILL

The National Industrial Conference Board announced that a recent study it had made indicates that four out of every five companies have adopted some form of training for industrial work in order to meet present and future needs for skilled workers. The survey, which covered 473 companies in various industries and in different parts of the country, indicates the time required for training ranges from one week to five years. Compensation for persons in training is shown to be at least 50 per cent of the regular rate in about 32 per cent of the companies.

DEATHS

HERMAN DIEDERICHS

On August 31, at Ithaca, N. Y., Herman Diederichs, dean of the College of Engineering, Cornell University, beloved and admired by engineers, died following a rare case of anemia. Dean Diederichs was a member of The American Society of Mechanical Engineers and its 1930 Melville medalist. He served also as chairman of its Board on Honors and Awards and its 1936 Nominating Committee. For 44 years identified with Cornell as student, teacher, and dean, successively, he was an authority in experimental engineering, having collaborated with the late R. C. Carpenter in a textbook on this subject published in 1910, and with W. C. Andrae in a work on mechanical experimental engineering, dealing with engineering instruments, in 1931. Interest in student activities, especially athletics, won for him the position of track adviser in 1907, and presidency of the athletic association, 1913 through 1925, and again in 1932, which later term he filled until he became chairman of the new board of athletic control.

Andrew W. Mellon, Secretary of the Treasury, 1921–1932, died at Southampton, L. I., on August 26. Financier, industrialist, patron of the arts, and benefactor of industrial research, his name lives in that of the Mellon Institute which he and his brother, Richard B. Mellon, established in 1913. The events leading up to the establishment of this institution were described by him in an address delivered at Pittsburgh, May 6, 1937, at the dedication of the magnificent new building in which it is now housed. In 1909, reading the book "The Chemistry of Commerce," by Robert Kennedy Duncan, then professor of chemistry at the University of Kansas, he was particularly interested in the last chapter "in which Dr. Duncan described his plans for industrial fellowship, by means of which industry could utilize the services of qualified scientists to solve its problems in much the same way as is being done here today." Enlisting his brother's interest, and securing the services of Doctor Duncan as director, were subsequent steps in the establishment of the Mellon Institute, whose first permanent building was opened in 1915.

Oxometer—Needed Machine

THE ATLANTIC MONTHLY

IN THE September, 1937, issue of *The Atlantic Monthly*, Albert Jay Nock tells about a much-needed machine that was, unfortunately, overlooked by the National Resources Committee in its recent 450,000-word report on "Technological Trends and National Policy."

The machine in question is called the oxometer, a contrivance of Mr. Nock's old friend Bill M. Aside from its remarkable performance Mr. Nock reveals little concerning this device. Its purpose, however, is to eliminate the bull from printed page and spoken address. Although, as Mr. Nock testifies, the result is the discovery that any article or book contains page after page of unsullied whiteness, and that any address is interrupted by long periods of restful silence, the utility of the device, for those who can stand the strong elixir of undiluted truth, will be gratefully acknowledged.

Like the National Resources Committee, Mr. Nock asks a lot of questions about the effect of the invention on social institutions—the Congress, the college, the newspaper, the law, literature, theology, medicine, and commerce (engineering not mentioned!)—and the answers he leaves to the imaginations of his readers. But honest men should not shrink from shouldering this additional burden of the implications of technological change. Bill's oxometer substitutes the accuracy of mechanistic regulation for the capricious vagaries of the editor's blue pencil.

North Atlantic Air Service

THE ENGINEERING JOURNAL

IN AN exhaustive paper entitled "North Atlantic Air Service, London-Montreal," by J. H. Parkin, to be found in the August, 1937, issue of *The Engineering Journal*, the author covers a variety of factors affecting the success of a commercial air service across the North Atlantic, such as potential traffic, choice of route, weather conditions, terminal organization and facilities, aids to navigation, and type and performance of air craft. Of special interest is a table of North Atlantic air crossings, beginning with the historic flight of Alcock and Brown from St. Johns to Clifden on June 14, 1919, and ending with

Mollison, Harbor Grace to Croyden, Oct. 30, 1936, for nonstop flights, and for flights by stages, that of Read and his companions in the NC-4 from Trespassy Bay to Lisbon via the Azores, May 16 to 31, 1919, down to the Oct. 18, 1936, flight of Blankenberg and others, from Sydney, N. S., to the Azores, Oct. 18, 1936. Sixty-five nonstop flights are listed, and 20 by stages. The table does not go beyond Dec. 31, 1936.

The North Atlantic Ocean, says the author, has been termed the greatest natural obstacle with which air transport is confronted. The barriers to be surmounted in overcoming this obstacle are those set by the length of the land-to-land flight and the severe meteorological conditions. Up to the present time, he asserts, these two have proved unsurmountable obstacles to the establishment of a transatlantic air service.

The minimum land-to-land distance that must be flown nonstop, he continues, if landings are not made on mid-ocean islands, is 1850 miles, between Ireland and Newfoundland. Numerous maps indicate the routes and the meteorological conditions encountered on them. Solely from the standpoint of nonstop flight, this distance presents no particular difficulty for modern aircraft. The economic operation of a commercial service over a nonstop stage of this length and over open sea, however, does present difficulties. The distance is considerably longer than the longest stage of any commercial air route now in operation and the overseas distance exceeds any flown commercially up to the present time.

In view of present efforts on the part of air services in this country and Europe to establish transatlantic commercial lines, Mr. Parkin's paper, with its maps, tables, and discussion of many phases of the problem involved, is especially timely. Appendixes deal with the depot ships of the Deutsche Luft Hansa, the Armstrong seadrome, a mathematical analysis of take-off conditions, the fixed long-run shore catapult, and the ice hazard.

Catapult Ships

ENGINEERING

VISIT to this country of the German seaplane *Nordmeer* stimulates interest in the seaplane catapult ships of the Deutsche Luft Hansa developed for the South American airmail service maintained between Berlin and Buenos Aires.

Two of the three catapult seaplane depot ships, the *Westfalen* and the *Schwabenland* (the second of which visited this country to launch the *Nordmeer* on its return flight) are reconstructed steamers. The third, the *Ostmark*, was especially built to perform all the duties of a floating seaplane base in tropical waters. Certain statistical details of the three ships are to be found in the article on "North Atlantic Air Service," *The Engineering Journal*, August, 1937, reported elsewhere in this section, and a more complete description of the *Ostmark* appears in the July 23, 1937, issue of *Engineering*.

The *Ostmark* has a length of 246 ft, a beam of 37 ft, and a displacement of 2000 metric tons. It is propelled by twin screws driven by two-stroke single-acting M.A.N. engines, each having 10 cylinders. The propelling machinery is located amidships, the exhaust from each engine passing through a swivel bend at the level of the lower deck to a short vertical exhaust pipe at the ship's side. Twin masts are stepped immediately forward of the exhaust pipes, to which they are attached, so that, the tie between them being disconnected, each mast can be swung out from the ship's side to allow a clear passage for the seaplane which is launched by means of a runway and catapult over the bow of the ship. The catapult runway is 136ft long and has an extension at the afterend capable of holding a second machine.

A crane, located in the afterpart of the ship, lifts the seaplane over the square stern and deposits it forward of the deck houses on the runway. It is electrically operated, has a lifting capacity of 12 metric tons at the maximum radius of 52 ft 6 in., and can swing through a full circle in one minute.

As the seaplane rises and falls on the waves, a varying tension is induced in a spring connection above the lifting hook. After the hoisting motor has been switched in and a locking lever released, an automatic gear assumes control and delays action of the motor until the upward velocity of the seaplane, resulting from the wave action, is equal to the lifting speed of the motor. The lift initiated by the wave is then continued by the motor, and the seaplane rises at this uniform speed as the wave falls away beneath it.

The seaplane, when being hoisted, is heading in the same direction as the ship, and after being swung through 180 deg to be deposited on the carriage, must be reversed before it can be launched again. A turntable is therefore incorporated in the portion of the runway abaft the catapult.

The catapult track consists of I-beams, machined on the top flange, the carriage sliding on four shoes which embrace the flange to prevent lifting. Brakes at the point of the runway where the seaplane leaves the carriage grip the latter and check its forward course.

Motive power for the catapult is provided by compressed air stored at 2275 lb per sq in. in a cylinder located beneath the runway, whence it is admitted to the operating cylinder which has a stroke of 17.7 ft. Rope pulleys mounted on the piston rod increase the velocity in the ratio of 1 to 6, and from them the hauling ropes pass over a system of guide pulleys in the central slot to a hook on the forward end of the carriage. The maximum velocity is 93 mph. Provision is made for tightening the cable before catapulting and for cushioning the piston as it approaches the end of its stroke. At the afterend of the catapult structure an apparatus is installed for testing the gear without actually launching a machine.

CO_2 From Flue Gas

POWER

A PROCESS of recovering CO_2 from flue gas for use in plants manufacturing that convenient refrigerant, solid carbon dioxide, is described in the August, 1937, issue of *Power* by D. H. Killefer and J. Welford Martin. The authors state that inasmuch as the major elements of cost of producing "dry ice" in existing plants are power and delivery expenses, an ideal situation for a producing plant would be at a power-producing unit near a population center that would permit the use of off-peak or incremental power in its operations. It would permit erection of a plant with a minimum of investment since much of the cost of an operating plant is that of the power-producing units, and it would further allow plants to produce within areas of relatively dense population and thus would avoid excessive transportation costs. These considerations led to the conclusion that an alliance between a dry-ice-producing unit and a steam power plant was desirable and stimulated a search for a process for recovering CO_2 from flue gas.

The Macmar process was evolved from a study of proposed methods, and is said to have showed itself satisfactory in laboratory trials, in a pilot plant, and in a full-scale plant with a daily capacity of 15 tons.

The process is described as being similar in many respects to

the alkali process usually employed, and the equipment used for it is practically the same. Flue gas (after suitable washing with water and dilute bicarbonate solution to remove dust, sulphur dioxide, and soluble impurities) is passed through a series of three packed towers or absorbers. In the second tower of this series is pumped hot (130 F) potassium-carbonate lye, and ammonia is added as required to give a substantial concentration in the gas mixture. Either anhydrous or aqua ammonia may be used. The lye from the base of this tower is cooled below 100 F and pumped into the top of the third or gas-exit tower. From there, after being reheated, it is pumped to the top of the first, or gas-entrance, tower. From the bottom of the first tower the lye carrying CO_2 in solution as bicarbonate is pumped into a lye boiler where CO_2 is released by heat. The lye thus freed from a large part of its CO_2 is recycled over the towers as already described.

The essential part of this new process is said to be the introduction of gaseous ammonia into the absorption towers down which potassium-carbonate lye is trickling. This gaseous ammonia readily reacts with the CO_2 in the flue gas even at low concentrations in the presence of moisture. So long as there are appreciable amounts of CO_2 and ammonia present in the atmosphere of the tower they will combine to form ammonium carbonate (or bicarbonate). The ammonium carbonate is a highly soluble solid and is immediately dissolved by the alkaline solution descending the tower. At temperatures around 130 F, ammonium carbonate is decomposed in the alkaline solution forming potassium bicarbonate and liberating ammonia to react with more CO_2. By thus performing the principal reaction of the absorption process in the gaseous phase, the resistance offered to the reaction by surface films separating gas and liquid is practically avoided. Some ammonia is carried over to the lye boiler in the absorbent solution in the form of carbonate and bicarbonate. This is recovered in the water condensed from the CO_2 gas evolved in the lye boiler and pumped back to the absorption tower.

Three types of absorption towers were considered: Bubble cap towers, spray towers, and packed towers, the last being preferred. Among several types of packing choice was made of steel turnings, which, if carefully selected and sieved free from small particles ($^1/_4$ in. mesh), are highly efficient. For desorption a standard lye boiler is used.

Curves showing the results relating to absorption efficiency of the Macmar process, as compared with the standard alkali process, in terms of percentage of CO_2 absorbed for various percentages of CO_2 in the flue gas, are given.

[For a note on packed towers for CO_2 recovery plants see MECHANICAL ENGINEERING, February, 1937, pages 114–115.]

Creep of Nonferrous Metals

BRITISH NON-FERROUS METALS RESEARCH ASSOCIATION

AVAILABLE published information relating to the creep of nonferrous metals and alloys is summarized by W. A. Baker in Research Reports of the British Non-Ferrous Research Association, research No. 58, Association series No. 449, June, 1937.

The data presented have been selected critically and include information on copper and copper alloys, nickel alloys, aluminum and aluminum alloys, and lead. Numerical values are in tabular form convenient for reference, with compositions of materials noted. Each table is followed by a list of papers on which the data are based, with a note on the contents of each paper. An index to all metals and alloys mentioned is given.

The Erren Engine

ENGINEERING

THE Erren engine, previously described in 1932 and 1933 in *Engineering*, has recently demonstrated further possibilities, according to a report in *Engineering* for July 23, 1937. The object of the demonstration was to illustrate the practicability and economy of employing the Erren engine utilizing hydrogen, coal gas, or water gas as fuel. Four engines, a Beardmore airless-injection, fitted in a coach, a Morris-car, and a National and a Krupp stationary engine, were demonstrated, the latter three on test beds, and were equipped with the Erren plant for running on gas.

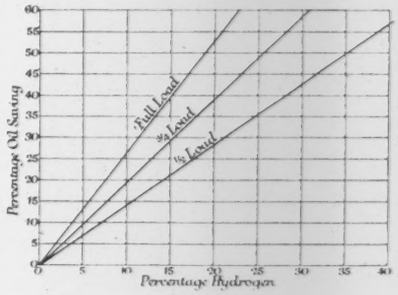


FIG. 1

Instead of the original method of admitting gas through additional poppet valves, the Beardmore, Morris, and National engines were equipped with a simple rotary valve. Gas is fed through a reducing valve to a balancing chamber, in the form of a vertical receiver, and thence to the rotary valve. The National engine, designed to develop 8 bhp on Diesel fuel, actually developed 10.8 bhp at 980 rpm on hydrogen. The usual Diesel knock was absent when running, under similar conditions, on hydrogen, and the exhaust was quite clear.

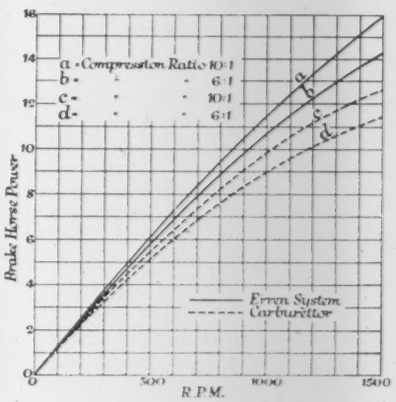


FIG. 2

The engine is arranged for running on a combination of gas and oil as well as on either separately, and the economy in fuel oil attained by introducing hydrogen is shown by three load curves in Fig. 1; the compression ratio of the curves is 15 to 1.

The advantages of the Erren system over the more usual method of introducing gas through a carburetor is illustrated in Fig. 2, which shows power curves at different compression ratios with the National engine using coal gas.

The essential feature of the Erren system is an arrangement whereby a full charge of pure air is received during the suction stroke, into which the gas is injected under any desired pressure during compression. The gas valve is located on the side of the cylinder block, and the gas is injected through a nozzle passing through the water jacket into the cylinder wall, an arrangement that adapts itself to a majority of existing engines.

Among the advantages are absence of carbon accumulations in the combustion space, absence of lubricating-oil contamination, exceptionally slow running without load, ease of starting in all weather conditions, and absence of carbon monoxide in the exhaust.

It is said that a further development is the application of the

Erren system to submarine engines. The fuel employed is hydrogen and oxygen, and the engine is designed to function below surface on the closed-exhaust system, so that there is no exhaust from the engine to the surrounding sea. On the surface the engine is arranged to operate with oil on the normal Diesel cycle.

Extruded Condenser Tubes

STEEL

IMPROVEMENTS in the method of manufacturing condenser tubes from copper alloys are described in the Aug. 9, 1937, issue of *Steel*. Although previously it was necessary to cast most tube alloys with the hole in place, in the new process tubes are made by piercing and extruding solid cast billets which have been machined to remove surface irregularities. This process is said to assure clean inner and outer surfaces.

Fig. 3 shows how the piercing and extrusion processes are

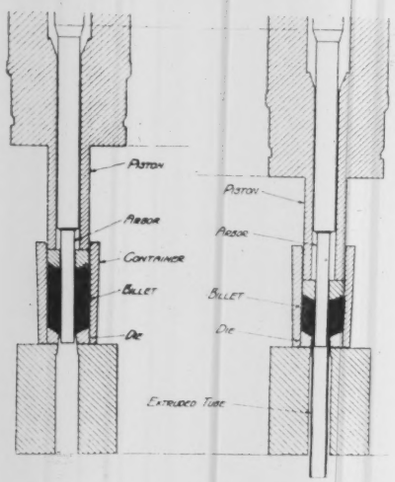


FIG. 3 PIERCING AND EXTRUDING COPPER TUBE

(At the left the billet is shown in the container with the piercing tool extending through the die. At the right the piston is pressing on the billet, forcing the metal through the die and around the piercing tool.)

performed. The heated billet is placed in a cylindrical container in the extruding machine and a hole pierced longitudinally through its center by a hydraulically operated piercing tool. After piercing the billet the tool projects through the center of the die which forms the bottom of the container. The tool thus determines the inside diameter of the tube. In the same operation a piston, of which the piercing tool is an integral part, presses on the billet and forces the hot plastic metal through the wall and around the tool to form a heavy walled tube. This tube is then cold-swaged over a mandrel, annealed, and drawn.

Design of Flat Springs

THE BERYLLIUM CORPORATION OF PENNSYLVANIA

REASONS for the suitability of heat-treated beryllium copper for flat springs are advanced in Bulletin D of the research department, The Beryllium Corporation of Pennsylvania, entitled "How to Design Flat Springs to Meet Definite Requirements."

Design formulas for deflection and working stress are given and discussed, and there follows comment on the properties of the spring material to be used, such as its elastic and proportional limits; the number of operations of the spring, involving the endurance limit; the changes in deflection permitted under a steady load, introducing elastic hysteresis and drift; how to secure better electrical conductivity; and the stability of spring shape. In all of these comments the relative value of beryllium copper as compared with certain other spring materials is presented by means of charts and tables.

High-Temperature Steam

THE STEAM ENGINEER

USE OF steam at temperatures as high as 900 to 1200 F in such processes as low-temperature carbonization of coal, torbanite, lignite, oil shale, bituminous rock, and similar materials may become of importance, says David Brownlie in an article entitled "Extra High Temperature Steam for Heating" in the August, 1937, issue of *The Steam Engineer*.

According to Mr. Brownlie, for more than three quarters of a century methods and processes of carbonization under low-temperature conditions, mostly, say, 800 to 1000 F, have been under consideration, using steam, or mixtures of steam and gases, as the heating medium, passed through the charge on the internal principle. No commercial success has yet been achieved with processes of this type, and until recent years, say until about 1925, the two major objections to the use of steam were difficulties with the separately fired superheaters and the net operating costs.

Apart from this steam has many advantages, being easily controlled, absolutely clean, and beneficial in the sense of reducing the natural cracking action on the oil or tar produced, that is when a yield of crude oil and not light oil only is the main consideration, owing to the heat and the catalytic action of the ash in the coal or other material.

Now, however, one of these primary problems has been solved, since superheated steam at 850 to 900 F is already standard practice for power stations, plants at 800 to 1000 F are operating, and there is evey possibility of steam being used at 1200 F.

The second problem, however, still remains; that is the high cost of the use of steam as a heating medium because of the latent-heat loss on condensation.

Mr. Brownlie describes several abandoned processes proposed since 1910 which have used high-temperature steam as the heating medium. There was the process developed from 1912 by Frederick Lamplough in which superheated steam only was used at a temperature of about 840 F, and the later Lamplough-Harper process. In the German Moeller process, which never reached the commercial stage, a vertical retort with internal heating either by means of steam or a gas high in hydrogen content was used, the entering temperature being from 930 to 1110 F.

The Turner process, developed by Charles Turner since about 1913, used a vertical mechanically continuous cast-iron or steel retort into which highly superheated steam was passed continuously at the bottom, generally within the range of 1058 to 1220 F. Pressure in the retort was allowed to rise to 4 or 5 lb per sq in. and then was suddenly released by means of mechanically operated valves, alternations in pressure taking place five to nine times a minute. Turner claimed that this alternate pressure control with sudden expansion of gases and vapors resulted in maximum recovery of low-boiling-point liquid fuels

A number of experimental retorts were operated at various places. The Trumble process, dating from 1922, by the late Milton J. Trumble, of California, was based on the principle of internal heating of oil shale, coal, and other materials by means of high-pressure steam at about 200 lb per sq in. and 1200 F mixed with heavy oil vapor. A semicommercial experimental plant was worked at Alhambra, Calif., for a number of years, but was abandoned at the time of Mr. Trumble's death.

Cement-Bound Molding Sand

AMERICAN FOUNDRYMEN'S ASSOCIATION

AT THE Steel Division session of the 41st annual convention of the American Foundrymen's Association, Milwaukee, Wis., May 6, 1937, Carl A. Menzel, of the research laboratory, Portland Cement Association, reported laboratory tests on portland cement as a binder for foundry sand. As reasons for recent marked interest in this use of portland cement, Mr. Menzel gave the following: (1) Efforts on the part of foundry technicians to improve the quality and reduce cost of castings; (2) the development and general availability of inexpensive high-early-strength cements; and (3) excellent results obtained with cement binder in a process used in a few European and American foundries. Mr. Menzel's paper concluded with the following recommendations:

For the facing of the mold only fresh, clean, well-graded silica foundry sand should be used. The sand should be mixed with about 10 per cent cement and a total of $4\frac{1}{2}$ per cent of water by weight of the dry materials. This damp mixture should be rammed in the usual manner and to the proper thickness. It can be backed up with a mixture composed of cement and a lower grade of sand or other material. Such a facing mixture, when made with high-early-strength portland cement and protected from loss of moisture for the first 24 hours, will have excellent strength and permeability for foundry purposes two or three days after molding, even though dried rapidly following the initial 24-hr moist period. If normal portland cement is used, the green strength will be lower and a longer curing period and greater age will be necessary to obtain the same set strength. Increasing the amount of normal portland cement would give adequate strength but would bring about an undesirable decrease in permeability and increase the lime constituents at the surface of the mold.

The facing mixture may be mixed and rammed in the usual manner but extended mulling should be avoided in order to reduce temperature rise and moisture loss. Mixtures at normal temperatures of 70 to 80 F should be rammed within $2\frac{1}{2}$ hr after mixing if made with high-early-strength cement, and within 4 hr if made with normal portland cement. Mixtures at higher temperatures, say 100 to 110 F, should be rammed as soon as possible after mixing but not later than one hour.

In the discussion which followed, Marshall Post, vice-president, Birdsboro Foundry & Machine Co., licensee of the United States patents, and sole agents of the Société d'Electro-Chimie for the granting of licenses in the United States and Canada, told of the experience of that company with the Randupson process.

Other discussers testified to the high quality of castings obtained by the use of the process and the time and space required for proper curing. Mr. Post pointed out that since the introduction of the process his plant had greater capacity than formerly because it was possible to rack cement molds and because the space previously occupied by drying ovens made an excellent storage area.

Penetration of Oil Sprays

THE PENNSYLVANIA STATE COLLEGE BULLETIN

LATEST as well as earlier results of extended studies on the penetration of sprays such as are used in Diesel engines, atomizers, paint sprayers, and oil burners, with primary regard to Diesel engines, are presented by P. H. Schweitzer in Bulletin No. 46, Engineering Experiment Station, of *The Pennsylvania State College Bulletin*, July 5, 1937, entitled "Penetration of Oil Sprays." The material is presented in four sections which deal with the motion of the spray tip, the real motion of the sprayed oil, the building-up period of the spray, and the accessory experiments. It is noted that a mathematical supplement is separately published and may be purchased.

The penetration of the spray tip in small, consecutive intervals was determined by a sensitive electric contact upon which the spray impinged, closing an electric circuit. The time required for the spray to reach various depths of penetration was determined by a "timed" contact in series with the spray contact.

With an oil spray of oil having a viscosity of 45 Saybolt seconds, an injection pressure of 4000 lb per sq in., an air density within the spray chamber of 15 atm, and a 0.0135 × 0.027-in. nozzle orifice, the penetrations noted were as follows:

Time, milliseconds	4	8	12	16	20	24
Penetration, in.	4.6	6.6	8	9.1	10	10.7

For other conditions the tip penetration can be computed by means of the following formulas:

Varying injection pressure

$$S = f(t\sqrt{p})$$

Varying orifice diameter

$$S/d = f(t/d)$$

Varying air density in chamber

$$S(1 + \rho_a) = f(t\rho_a)$$

in which S is the penetration in inches, t the time from the beginning of the injection in seconds, p the pressure head in pounds per square inch, d the orifice diameter in inches, and ρ_a the air density relative to the atmosphere.

Tip-penetration data are of interest but they are useless for knowing the real motion of the oil particles. Tip velocity is really the rate at which the hole in the air made by the oil spray grows. Data on the real motion of the oil itself (which is much faster than the tip) was obtained by means of a "shielded" ballistic pendulum. The main findings in this investigation are as follows: (1) The issue velocity can always be taken as $0.95 \times 2gh$, where h is the pressure head of the oil injected; (2) the air resistance is proportional to the square of the oil velocity and to the first power of air density, and is independent of the orifice diameter; and (3) the air resistance decreases with increasing oil viscosity but is not sensitive to normal changes in specific gravity. By a simple graphical method shown in the bulletin the penetration can be determined for various conditions.

Sprays of short duration have been investigated to obtain information on the building-up process. The experiments were made with a slotted disk and with a very quick-acting electromagnetic spray valve. The tests showed that the building up of the spray is extremely rapid, about one thousandth of a second for a 6-in. spray. This time interval is so short that the spray in a Diesel engine is not influenced by the injection duration. Exceptions to this are sprays at extremely short duration

(they are "softer"), impossible to produce with conventional injection system.

The chapter on accessory experiments includes: Testing of sprays for concentricity, weight of discharge tests, rate of discharge tests, experiments with the tipping cup, and experiments with the electric balance.

Shellac Comes Back

INDUSTRIAL BULLETIN OF ARTHUR D. LITTLE, INC.

INTEREST in plastics continues to engage the attention of mechanical engineers, always intent on developments in materials. That natural products are responding to the competition of synthetic materials is illustrated in the following extract from the August, 1937, issue of the *Industrial Bulletin* of Arthur D. Little, Inc.

Among the important scientific developments at the beginning of the twentieth century was the improvement of one of the world's oldest available materials—shellac. A decade later, synthetic resins began to take the place of shellac in the manufacture of plastics, but, at the present time, interest has been revived in the use of shellac as a raw material. In spite of the extensive development of the synthetic-resin industry, many of the properties of shellac have not yet been duplicated, and, as scientific controls have served to regulate the purity and quality of shellac, manufacturers have begun to turn their attention back to it.

The thermoplastic properties of shellac were utilized even in prehistoric times for the manufacture of cast and molded articles. At the beginning of this century, it was found that the plastic properties known to the ancients could be utilized in the large-scale manufacture of resin plastics. During the World War, shellac prices became prohibitive, and manufacturers began to find synthetic resins suitable for plastics.

Shellac was frequently at serious competitive disadvantage. It was intermediate between the two clearly defined classes of resins—those that harden permanently when once heated (thermosetting), and those that become plastic each time they are heated (thermoplastic). Price fluctuations and variations in the quality of the raw materials were additional reasons for the failure of shellac to maintain its position in this field. Color and resistance to water, alcohol and heat were unsatisfactory, and no program had been undertaken to meet these objections, distributors depending upon markets still held by properties for which shellac remained unique.

No plastic has yet been found that is as satisfactory for phonograph records; shellac reproduces with amazing fidelity every detail of the sound track of the master record, and all high-quality records for transcription and instruction in foreign languages are still made from it. Because of its excellent dielectric properties, shellac is held in high favor in the electrical insulation industry, where it is used in insulating varnishes, molded-mica insulators, insulating cloth, and laminated tubes. It is still used in the manufacture of adhesives and cement, sealing wax, and special inks.

Recently shellac has again come forward. It is now definitely competitive as a plastic material with many synthetic resins. Responsible for this renewed interest in shellac are the research programs instituted by governments and private organizations. Through the efforts of these groups, the particular requirements of shellac users are determined, and in conjunction with those in the trade in India, specifications are drawn up to cover these requirements. More enlightened growing practices are manifesting themselves, with attempts to cultivate the lac from which shellac is obtained, and to fertilize and prune the trees on which it is deposited. The older manufacturing processes by both native and European manufacturers are giving way to processes by modern methods under technical control with the advantages of uniformity and cleanliness, thus producing material which will more closely meet the ever-changing demands of the consumers.

Probably more has been learned about the chemistry and modifications of shellac in the past five years than in the preceding 1500. More important among the improvements in the methods of manufacturing shellac and their application in the industries are the reconditioning of old and deteriorated shellac, improvement of the weather and water resistance of shellac varnishes, bleaching of the lac, modifying the properties of shellac by combination with sulphur, urea and polycarboxy acids, and the utilization of shellac and its by-products in making new plastic molded articles.

The Indian Lac Research Institute has made a general study of the physical properties of various modifications of shellac plastics. They have incorporated phenol-formaldehyde resin in shellac molding powders and report that these compositions can be ejected from the mold at the temperature at which they are cured.

Dr. William Howlett Gardner, conducting research for the industry, has accelerated the cure of shellac plastics and obtained molded articles of improved thermal, mechanical, and electrical properties. It is indicated that a higher melting point, a closer range between softening and melting points, highly improved film-forming qualities, water resistance, and dielectric properties can be achieved.

The future of shellac is definitely bright, provided speculation does not jeopardize its price level or adulteration its quality. Shellac importers anticipate steady growth in world consumption, as better agricultural methods, improved manufacturing conditions, and a more highly specialized product become established in the industry. They rely upon shellac to hold its own in established fields through its unusual combination of qualities, and expect to extend its fields of usefulness in the plastic and surface-coating fields as the fruits of present research become available.

Machinery-Industry Accidents

NATIONAL SAFETY COUNCIL, INC.

ACCIDENT rates in the machinery industry, 1936, are summarized and tabulated in a pamphlet bearing that title published by the National Safety Council, Inc. The outstanding facts concerning 1936 experience are as follows:

(1) 1936 injury rates averaged 9.10 for frequency and 0.82 for severity in 262 plants which worked 538,580,000 man-hours during the year. These rates are well below corresponding averages of 13.57 and 1.64 for all industries.

(2) The machinery industry ranked ninth in both injury rates in a list of 30 major industries.

(3) The 1936 frequency rate is one per cent below the 1935 rate, but the severity rate is up 12 per cent. These changes compare with a reduction of one per cent in the average frequency rate of all industries and an increase in severity of five per cent.

(4) The decrease in the frequency of disabling injuries since 1926 amounts to 43 per cent, which is 18 per cent less than the average reduction by all industries. Severity has declined 38 per cent during this period against a reduction of 41 per cent for all industries.

(5) Large plants had the lowest injury rates during 1936.

(6) Middle-sized plants had the best results in comparison with 1935.

(7) Manufacturers of fine machinery and instruments had the lowest injury rates during 1936, averaging 4.33 for frequency and 0.25 for severity.

(8) Manufacturers of agricultural machinery and implements made the largest improvement over 1935 by reducing frequency 20 per cent and severity 32 per cent.

(9) Reports covering 220 fatalities and permanent partial disabilities occurring during the last three years show that "hazardous arrangement" and "improper guarding" are the principal mechanical causes of these injuries. The principal personal cause, on the basis of the same experience, is "wrong attitude."

(10) The most important types of compensatable accidents in the machinery industry, according to state reports, are "handling objects" and "machinery," which account for 55 per cent of all types.

(11) General Time Instruments Corporation, Westclox Division, La Salle, Ill., holds the best known all-time no-injury record in the industry—11,114,600 man-hours.

Odor Control

REFRIGERATING ENGINEERING

REMOVAL of odors in air conditioning by means of solid adsorbents, says F. H. Munkelt in the June, 1937, issue of *Refrigerating Engineering*, is the only one that is effective, and the use of activated carbon manufactured from coconut shells for this purpose is considered by him. Coconut-shell activated carbon, he asserts, is very active in the adsorption of hydrocarbons and organic gases, in which class fall most of the odors with which his paper is concerned. On the other hand this material has a practically negligible activity toward water vapor.

Coconut-shell carbon has high adsorptive capacity, which is important because it makes for long life between revivifications and attendant low operating cost of the odor remover, and high density, which makes possible apparatus with smaller space requirements than would be practicable otherwise. Because of its hardness and structural strength it is not easily abraded and does not settle or dust off.

The more important odors encountered in air conditioning, the author explains, are butyric and valeric acids, which are the common body odors; alcohol and the flavors generally associated with liquors; pyridine, which is the odor from burning tobacco; essential oils as used in perfumes; acrolein, which is generated from frying fat; and finally, cooking odors. The concentration at which odors become noticeable varies considerably. For instance, butyric acid (body odor) can be detected in a concentration of only 0.0000624 ppm; pyridine (burning tobacco) in a concentration of 0.0024 ppm; and some of the essential oils as much as 0.066 ppm. The breakdown point, or point at which odor begins to pass through a relatively thin bed of carbon through which an odor-bearing air stream is flowing, is less than the adsorption capacity of the carbon and must be determined for each velocity, thickness of bed, and grading of carbon. The bed may then be designed for a long service life.

When odor-remover equipment is applied to an air-conditioning system for the purpose of improving the economy of the system, the most suitable location is usually on the recirculation (return-air) duct. Rarely will conditions or convenience prefer the supply duct. But, if located on the recirculation duct, there is the advantage over the supply duct of a smaller quantity of air to be treated and, furthermore, the odors are removed before they have had opportunity to contaminate filters, washers, or coils. Partial treatment is feasible and sound, provided conditions do not demand the complete removal of the odorous gases. For all odors, there is a degree of concentration below which the odor does not affect the olfactory nerves sufficiently to be noticed by the subject. Complete removal from a portion of the air will, therefore, be enough in most cases. Treatment of an amount equal to the amount deducted from the new air supply and added to recirculation will, in most cases, give the desired results.

The best arrangement is a by-pass with a separate fan of sufficient capacity to handle the amount to be treated at the resistance of the odor adsorbers. The load on the main fan will then not be increased. The by-pass arrangement works out particularly well when applied to existing systems, where it may be desired to add considerably to the air flow in the recirculation ducts. In this case a by-pass relieves in part the additional resistance which would fall on the main fans.

The apparatus which has been developed is simple and flexible. Small canisters, each capable of handling 20 to 40 cfm, are removably attached to a manifold plate, which in turn is installed in the duct. The cross-sectional area required is approximately the same as that required for the dust filter, and the resistance is no higher, a good average being 0.18 in. water gage. It is good practice to place a filter in advance of the adsorbers, to prevent dust accumulating on the adsorbers and causing a change in resistance or a reduction in life before cleaning is required. In most air-conditioning applications, the service life can be expected to reach three to five years.

Eye Safety

GREATER NEW YORK SAFETY COUNCIL

IN SPITE of all that has been said and written about eye safety there seems to be a continuing need for emphasizing the importance of safeguards and treatment. In April, 1937, at the eighth annual convention of the Greater New York Safety Council, Dr. Elbert S. Sherman, attending surgeon, Newark Eye and Ear Infirmary, Newark, N. J., had some practical suggestions to make on the subject of eye safety for small industrial plants.

According to Dr. Sherman, the greatest number of eye injuries in his community occur in the metal-working trades. Most of these injuries, he says, are caused by flying particles of metal, abrasives, and the like, and are trivial in nature in that recovery is usually rapid without loss of time from work or impairment of vision. However, about 4 per cent are of such severity that more or less loss of vision results and from a compensation standpoint are the most expensive of all nonfatal injuries. In records of 100 cases, 62 per cent were caused by using hand tools and 20 per cent by particles of metal from metal-working machinery; less common injuries were perforations by wire, springs, tools, nails, and glass. In 38 per cent the final result was blindness or very great impairment of vision.

Dr. Sherman makes the statement that a very large percentage of injuries occur in small shops and garages, in many of which protection is almost entirely neglected until a serious injury develops. The same principles and practices should be observed in a small plant, he says, as are established routine in large plants able to afford the services of a safety engineer. In any case responsibility lies with the management. Why, he

asks, are there four or five times as many accidents in some plants, both large and small, as in others of comparable size in the same industry?

Defective vision, he asserts, is a not infrequent cause of accidents. Assuming that the best procedure, that complete eye examination by an ophthalmologist is, or is thought to be, unfeasible, the vision of all employees should be tested and recorded both at the time of employment and periodically thereafter. Even when carried out by unauthoritative tests, this is better than nothing and will disclose the fact that between 20 and 30 per cent of those examined have visual defects which need expert attention. An ophthalmologist can be found in most communities who will cooperate to the extent of charging minimum fees for complete eye examination for such a group. Arrangements can also be made with a dispensing optician to supply glasses at a reduced price. Besides reducing liability to accidents, the record of visual acuity obtained is sometimes of great value in determining loss of vision resulting from subsequent eye injury.

As to the first-aid treatment of eye injuries, Dr. Sherman's advice is to let well enough alone. The removal of a small foreign body in the cornea may seem like a simple procedure, he says, but unskillful handling causes damage to the surrounding tissues and often sight-destroying infection.

Certain types of serious injury may at first seem trivial to an inexperienced observer, or be completely overlooked. In many injured eyes there are old optical defects or pathological changes, the prompt recognition and evaluation of which are often important in making an estimate of the permanent disability resulting from the recent injury. An experienced ophthalmologist will discover and record such defects. If, after a lapse of several months, a compensation claim is made for alleged impairment of vision, it may then be too late to separate the percentage of disability that should be charged to the old condition, from that resulting from the recent injury.

Concerning the immediate or first-aid care of an eye injury, the best treatment in most cases is leaving it alone. For chemical burns, whether acid or alkaline, the eye should be flushed freely with clean water as soon as possible. Foreign bodies which are not embedded may be removed by wiping gently with a clean, moistened, cotton swab. If there is a wound, the eye should be covered with a sterile gauze dressing. Further than this, shop treatment may do more harm than good. As a rule it is better to send eye injuries to an ophthalmologist as soon as possible.

Big Business in the United States

(*Continued from page 738*)

ployed by the eight largest firms and 91.4 per cent by the four largest. At the bottom is women's clothing with only 3.7 per cent of its workers employed by the six largest firms and 2.1 per cent by the three largest. In 46 of the 82 industries more than one half of the wage earners were employed by the six largest concerns. A consistent subclassification of the 82 industries in this list would be difficult and probably not useful; the authors did not attempt one. It is, however, easy to notice the pile-up of the highly competitive textile industries at the bottom on this measure of concentration. The heavy industries are spread generally through the middle while the most highly concentrated industries include such products as cigarettes, copper, photographic equipment, explosives, matches, sewing machines, and typewriters. A similar story on concentration is told when value of products in each industry is used as an index of concentration in place of number of workers employed.

Chapter 4 deals with the importance of the large corporation (in 1933) as measured by assets and income. As this is directly along the lines set out earlier by Berle and Means, it is regrettable that the results found by the Fund are not in all cases directly comparable with those reached in this earlier study. The Fund finds that 594 corporations owned in 1933 53.2 per cent of our corporate wealth with manufacturing, public utilities, and finance accounting for all but 49 of these corporations. If financial corporations are excluded, 375 out of 287,575 or 0.13 per cent of all nonfinancial corporations owned 56.2 per cent of the total corporate wealth. This may be compared with the Berle and Means figures on or about January 1, 1930, which showed that 200 out of something over 300,000 nonfinancial corporations controlled 49.2 per cent of our corporate (other than banking) wealth. The assets measure thus indicates that the concentration of corporate wealth was at least as great in 1933 as at the end of 1929. Unwritten agreements, interlocking directorates, trade associations, political influences, etc., all necessary in a complete statement of the real extent of concentration, are of course not evaluated in the foregoing measure. This picture of concentrated wealth is made sharper in the light of the fact that at the other end of the scale there were 211,586 corporations with average total assets of less than $50,000. Ninety-five per cent of all corporations had less than $1,000,000 assets each and they owned less than 15 per cent of all corporate wealth.

A similar state is evidenced by the Fund's study of corporation incomes. Only 69 corporations, or 0.06 per cent of the total, qualified on the $5,000,000 or more net-income standard, whereas they received 30 per cent of total corporate net income. On the other side, almost two thirds of all corporations had less than $1000 annual net income each. As would be expected, public utilities including transportation were leaders by this measure of concentration, with 68 per cent of their total income going to the giant corporations in that field. At the other extreme was finance with 18 per cent.

SOCIAL AND ECONOMIC EVALUATION LACKING

There is no question but that the Twentieth Century Fund has done creditable work at figure finding. It is, however, somewhat regrettable that its competent staff did not make at least a modest attempt at an economic and social evaluation of the results—an analysis, say, comparable to Berle's legal critique as presented in "The Modern Corporation and Private Property." For some years we have been favored with many data on big business—none, admittedly, better presented than in the volume under review—but the major issues on big business, aside from the simpler economies and abuses discussed in every textbook, are still reasonably open questions. It is a fact that our ignorance in this field is more manifest in the analytical than in the statistical side. Admittedly, the superficial fact-exposé literature on big business—such as the book by Harry Laidler[3]—is probably less useful in the long run than strictly statistical source books. But what seems to be necessary is more work along a line which would combine some of our accepted theoretical equipment[4] with factual material such as is found in this Twentieth Century Fund survey and its predecessors.[5]

[3] "Concentration in American Industry," by H. Laidler, Thomas Y. Crowell Company, New York, 1931.

[4] See, for example, "The Theory of Monopolistic Competition," by E. H. Chamberlin, The Harvard University Press, Cambridge, Mass., 1933.

[5] As an example of such work, see "The Decline of Competition," by Arthur Robert Burns, McGraw-Hill Book Co., New York, 1936.

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers in Previous Issues

Automobile Industry and Young Engineers

To the Editor:

Two basic kinds of technical engineering work are found in the automotive industry; one is developing products for production, and the other is fundamental research for development of basic ideas. Both have certain characteristics in common, but each requires men with slightly different backgrounds and methods of thinking. One has to do with the solution of immediate problems and the other with preparation for the future and development of new industries.

In neither case, can ready-made engineers be found. Colleges can train their students in using the fundamental tools of science, but they have no way of foretelling exactly the kind of work that the boys will finally find to do and, consequently, cannot train them for specific jobs. Industry must use some method of its own to fit the young engineering graduate into the type of work that it has for him to do.

In reviewing Dean Freund's paper,[1] one will find that a large majority of the characteristics which he has found to be of greatest value to engineers engaged in development and design are those which can only be obtained from experience within the industry. Practical common sense, judgment, broad experience, familiarity with the product, and experience in the field cannot be fully developed in any college engineering course but have to be gained from actual experience. Any training program that is laid out for young engineers taking their place in the automotive industry should concentrate on the development of these characteristics and not attempt to review courses already pursued in college. In other words, we must assume that engineering colleges are adequately equipped to teach basic engineering courses just as they must assume that we are equipped to develop and build automobiles.

Selecting men to be trained for development in automotive-engineering fields must be done carefully. As Dean Freund has pointed out, the automotive field is colorful and fascinating to the young engineering graduate. Because of this, more young men apply for positions than can be absorbed. Our job is to select and locate them in such a way that they will not become misfits in the industry.

Deans of our high-grade engineering colleges can be relied on to select some of their outstanding students. These are picked on the basis of scholastic achievement, participation in extracurricular activities, and those intangible characteristics making up what we call "personality." If a student has a good fundamental background in the basic sciences, we have found that, by employing him for a probationary period in engineering work, we can develop those latent characteristics which we feel are essential to his future success.

We assume that these men have adequate technical training to work as engineer's helpers. During their probationary period of employment we observe and rate them on the following characteristics: (*a*) creative ability, (*b*) perseverance, (*c*) faculty of observation, (*d*) enthusiasm and aggressiveness, (*e*) ability to cooperate, (*f*) health, (*g*) technical training, (*h*) intellectual honesty, (*i*) conduct, and (*j*) character and morals. A student who is rated by four or more men with whom he has worked or studied, and receives an average grade of 85 per cent or better, is worth considering for a permanent position after graduation.

No doubt, other satisfactory and efficient ways of locating young engineers qualified for further training for positions in the automotive field exist. Whatever the method, complete cooperation is absolutely essential between the college faculties and the engineers in industry who will supplement this training with their experience.

Kenneth A. Meade.[2]

To the Editor:

The approach to the problem of fitting the curriculum of an engineering school to the requirements of the automobile industry is, indeed, a sound one—principally, on account of its directness. The picture of men and conditions within the engineering departments is, in the main, fairly accurate, fully acquaints the "young hopeful" with the things that he will be up against, and should fully protect the industry from the applicants who "can't take it." On the other hand, to say that all engineering officials are so harassed by each day's problem that they have no time to plan or even think about the systematic development of succeeding generations of engineers is unfair. This condition may have been general a few years ago and still does exist in some of the smaller and inadequately financed companies, but the industry is now stabilized to the extent that, at least, the larger companies now have plans calling for development of personnel to meet their future requirements. In such instances, the major executives are taking active interest in this work of planning.

In regard to the amount of experimental work done, in comparison with actual designing from formulas, this only applies to radically new features, and the effect of mass-production problems and the cost of equipment to produce a given model have a greater effect on the percentage of experimental work than the absence of engineering data upon which a design can be safely based. The demand for maximum results from a given amount of material, as brought about by the competitive situation, also influences the amount of test work employed. Ours is a young industry, but it is also a highly technical one. An appreciation of the production problems by his staff is what the chief insists upon, and this attitude of mind, more than any one thing, has given him the reputation of being "hardheaded" plus the fact that most men holding key positions in the engineering departments grew up with the industry and not in it. They fully realize that, regardless of how the industry attained its present position, its future depends upon technical advances.

All sound planning calling for the development and perpetuation of an engineering organization must provide room for both the engineering-college

[1] "The Automobile Industry and Young Engineers," by C. J. Freund, Mechanical Engineering, April, 1937, pp. 227–229.

[2] Research laboratories division, General Motors Corporation, Detroit, Mich.

senior and the so-called practical man. Patience on the part of the executive staff is necessary to their development, but their final place in the picture is determined by their own efforts and how they, as engineers, appreciate the relation of their problems to the remainder of their organization.

J. M. CRAWFORD.[3]

TO THE EDITOR:

Dean Freund has covered his subject in a thorough manner in pointing out to the young engineer how he should prepare himself. In one question, he asked "What manner of men must they be?"—manner, I take it, meaning behavior, demeanor, conduct, deportment, or one's idea of his moral responsibility for what he does. In that statement, I find one of the highest inbred qualities of a desirable employee. I fully realize that Dean Freund was not writing a sermon. However, I feel that, in Table 2, "character" should have been included. The young engineer should be impressed that this qualification is indispensable to his future advancement. Many times, too little value is placed on one's moral sense and character. I would rate it of higher importance than any of the qualifications listed.

L. J. SCHRENK.[4]

TO THE EDITOR:

Mr. Meade expresses a viewpoint which has fortunately become more and more common among American corporations and employers, namely, that the industry must accept responsibility for the specific preparation of the young engineering graduate for the particular work to be given him by his employer, and that the colleges cannot possibly produce graduates ready-made for each and every opening in the industries.

All this has long been understood by the larger employers and those with the more intelligent personnel organizations, but college officers still encounter the employer who complains that "the young graduate you sent us last week hasn't done any better in our drawing room than any of my old timers who never went to college at all."

Unwittingly, no doubt, Mr. Crawford introduced a lesson for the college faculties when he wrote that "An appreciation of the production problem by his staff is what the chief insists upon . . ." In recent years emphasis has very properly been placed in the engineering colleges upon scientific studies and research. This was an inevitable reaction from the "practical engineering" of former years. But the movement may have overreached itself, so that engineering teachers incline to forget that engineering is, after all, an economic thing, and train young men who are competent or even brilliant scientific thinkers, and who can produce a machine or structure which can satisfactorily perform the function required of it, but who have never been taught to realize that the machine or structure must be built or manufactured. There is much that cannot be taught in college but there should be no great difficulty involved in making it clear to students that engineering devices must both serve their purpose and lend themselves readily to production.

As Mr. Schrenk points out, character is a primary requirement in automotive engineering as, indeed, in any other branch of the profession. Probably it should have been clearly stated in the original paper that a good character was taken for granted in the discussion, and that the purpose of the paper was merely to analyze as well as possible the relative value of qualifications which are peculiar to the automotive industry and less universally in demand than good character.

This statement cannot be closed more appropriately than by thanking those gentlemen who have so generously assisted in the preparation of the paper, or contributed to the discussion. Their help is very much appreciated.

C. J. FREUND.[5]

[3] Chevrolet Motor Company, Detroit, Mich.

[4] General superintendent, Public Lighting Commission, Detroit, Mich. Mem. A.S.M.E.

[5] Dean, College of Engineering, University of Detroit, Detroit, Mich. Mem. A.S.M.E.

Grinding Cemented-Carbide Milling Cutters

TO THE EDITOR:

The points emphasized in this paper[6] should be condensed and posted in every tool-grinding room using tungsten-carbide-tipped cutters. Practically every point made applies with equal force to the care and proper grinding of high-speed steel cutters. However, I do not agree with the statement in the opening sentence to the effect that tungsten-carbide cutters present problems in grinding that are not encountered with high-speed steel cutters, preferring to say that these problems are not recognized in handling cutters of the latter type.

Grinding with a cup wheel rather than a disk wheel because the former has a constant peripheral speed is the slightest reason that can be advocated. The main reason is that grinding tungsten-carbide or high-speed steel tools with a cup wheel produces a flat clearance behind the cutting edge instead of a weak concave clearance that is conducive to breakdown. The cutting edge on all tools should always be backed up to the point where the heel does not drag on the work. This is secured by keeping clearance angles small and not only avoids chatter but provides the maximum volume of metal to absorb frictional heat.

Both tungsten-carbide and high-speed steel milling cutters are benefited equally by rigid supports when being ground or in use. Radial or axial runout in either type of cutter which imposes an undue share of the work on a few teeth indicates carelessness and is seriously detrimental.

Breakdown of the cutting edge should be checked in its early stages to prevent excessive removal of metal when resharpening tungsten-carbide or high-speed steel cutters, and absence of a saw-tooth edge is desirable in both types.

In discussing the design of carbide-tipped inserted-blade cutters, rigid anchorage of the blade in the body is mentioned, but maximum backing-up of the blade by the body is specially stressed. Some years ago, a builder of milling machines who marketed tungsten-carbide cutters as an auxiliary line used the trade-name "Full Backed Cutters" to emphasize this point. This practice is equally valuable in designing high-speed steel inserted-blade cutters, and the company with which I am connected commonly followed it for years before tungsten carbide made its appearance as a cutting agent. Mention is also made of setting the blade at the proper angle for the material to be cut, and Table 3 is a useful contribution. Suggesting only four teeth in the reference to cutting aluminum and the lighter metals offers no enlightenment. If such considerations are mentioned in pitch of teeth rather than number, a guide to proper procedure is given, regardless of the cutter diameter. Although standardization of the number of teeth or their pitch was attempted by this same milling-machine builder and is again being tried by one of the companies manu-

[6] "Grinding of Cemented-Carbide Milling Cutters," by Hans Ernst and Max Kronenberg, MECHANICAL ENGINEERING, April, 1937, pp. 221–226.

facturing tungsten-carbide-tipped tools, the range of possible applications is too wide and too little exact knowledge is available to warrant an attempt at crystallizing these data at present. While use of tungsten-carbide-tipped cutters has been of outstanding benefit in many instances, the better practice at present would be to seek expert advice concerning their design and application rather than attempt to have a standardized list of cutters and select the one that the foreman or the shop superintendent considers to be suitable for the work.

While this paper considers only tungsten-carbide-tipped inserted-blade cutters, instances are not too infrequent where inserts of this material alone have been put into thin saws and other solid cutters with beneficial results. Although the expense entailed was great, it was offset by the increased production obtainable.

Having the tooth rest abut against the back of the cutter tooth is not good practice with any inserted-blade cutter and particularly so where the blades have tungsten-carbide tips. The back of the blade is serrated and, while fairly uniform, is far from dependable where the close accuracy of grinding is required. The face of the blade insert is always ground, and this face, just outside of the tip, should always be used as the index point.

Finally, let me add all the emphasis that I can to this sentence, "In each shop, a man should be selected and trained in grinding milling cutters with cemented-carbide blades," which should read "for grinding all cutters." Profit or loss on a shop's investment in milling cutters, indeed on the capital investment in milling machines, may as likely be determined in the care and maintenance of the cutters as in their use. This is one of the places where so-called non-productive labor can make an outstanding contribution to the ultimate results of so-called production labor. Only high-grade, intelligent, and well-paid men should be employed for this work. If boys are used, as is so often the case, they should have critical supervision. For best results, closest cooperation should always be maintained between grinding and production departments.

A. N. GODDARD.[7]

TO THE EDITOR:

This paper has covered the grinding of inserted-tooth milling cutters thoroughly. Our experience with this type extends over several years and a large number of cutters varying from 3 to 18 in. in diameter.

Use of Brinell-hardness comparisons has never proved to be very satisfactory; we have found the A scale on a Rockwell machine to be much more satisfactory. This is a reading taken on the C scale of the dial, but with a load of 60 kg instead of 150 kg which is regularly used in determining C-scale hardness. These comparative figures are satisfactory, and the breakage of diamond brailles is less with the lighter load. Using hardness figures as an indication of grinding problems is true except that softer grades of carbide containing tantalum and titanium present problems equally as difficult as those experienced in grinding harder grades of straight tungsten carbide which forms the basis of practically all cemented-carbide tool tips.

We were told that the inserted-tooth cutter equipped with carbide-tipped blades has to be held to less runout than the high-speed steel blades to prevent overloading of the carbide tips. Our experience does not bear out this statement. We have found that the only reason for this close limit on runout is better finish on the surface milled. When the proper speed and grade of carbide is used the blades can be loaded up to 0.025 in. feed per blade without any trouble. We do find that when carbide-tipped blades are used better finish is expected.

In discussing the use of disk and cup wheels in grinding cutters, the statement was made that the latter wheel was preferable in grinding carbides. This is true when grinding milling cutters but does not hold good for single-point tools. The description of large areas in contact with the tips when cup wheels are used is correct, considering the cup wheel with a face perpendicular to the wheel axis. We recommend cup wheels having a face that is dished at an angle of 20 deg with a plane perpendicular to the axis. Such a wheel allows a small area of contact between wheel and work. This also applies to diamond-wheel grinding as large areas of contact with straight-face wheels frequently cause bond softening and diamond loss due to heating of the wheel.

Wheel speed is an important factor in wheel selection and wheels can be designed around standard machine-spindle speeds. A surface speed of approximately a mile a minute will give excellent results with both silicon-carbide and diamond wheels when the correct wheel is used.

Use of a coolant on hand-operated grinding machines presents some hazards to tip grinding. These are

(1) Flow does not always reach the tip in large volume before grinding action has started.

(2) Operator will divert the flow for a few seconds to see the work and the returning coolant strikes a heated tip.

(3) Operators on hand-operated machines like to see the sparks which are largely from the steel. Our experience has been that to go by sound is better.

In Table 2, certain wheel recommendations are made which our experience does not confirm. A carborundum T wheel is the softest we use and we seldom, if ever, use silicon-carbide wheels for this work with a grain size finer than 80.

Diamond wheels are recommended for grinding carbides, and an indicator should be used in setting the wheel to be sure the runout is not more than 0.001 in. When the face of the diamond cup wheel cannot be made to run true, it is not lapped or trued with the back, but all truing up is done on the back of the wheel. We have not found that "coolant must be used with a diamond wheel." Sometimes, an occasional wiping will suffice, and, in many cases, we use the wheel dry. When we do use a coolant, light mixtures of "soda water" will do a good job. Speeds of diamond wheels can be too great with the result that the temperature in the wheel rises which loosens the bond and allows the diamonds to be lost. In fact, good results are being obtained on standard machines running at normal speeds.

Where the number of cutters ground will warrant the expense, wheel, cross, and table feeds can be automatic. A well-designed machine with these automatic features will turn out finished cutters, both carbide and high-speed steel, which are ground as accurately as with hand-operated machines. Automatic grinding is superior to hand grinding as wheel wear and stock removal can both be predetermined and compensated for on the automatic machine. This permits wet grinding. Regardless of the devices used, the cutter will not be any more accurate than the machine, the adapter, and the relation of the cutter face to the bore.

JAMES R. LONGWELL.[8]

TO THE EDITOR:

The subject has been well-handled by Messrs. Ernst and Kronenberg; however, I do not agree with the statement that their more constant surface speed

[7] President, Goddard & Goddard Co., Detroit, Mich. Mem. A.S.M.E.

[8] Chief engineer, Carboloy Company, Inc., Detroit, Mich.

makes cup wheels better to use. They are to be preferred in general, but disk wheels would be better for roughing as they do not wear as rapidly as the thin edges of a cup wheel. The disk wheel will not be good for finishing because it produces a concave surface which weakens the cutting edges, whereas, the cup wheel produces a flat surface and a more supported edge. The latter has less contact area in taking the same width of cut, as a straight line is the shortest distance between two points, the top and the bottom of the cut. It also is best for all-around machine grinding for tungsten carbide.

The angles, as explained, are good, but I would suggest that for fine finishing, an additional 2 or 3 deg should be provided as a lead angle on the cutter face. These slight lead angles thin out the chips at the finishing point and produce a fine finish on the work. The lead angles should be longer than the feed per blade. Good practice dictates grinding angles to a cutter-clearance protractor.

Depending on a wheel-truing device alone is impossible. The proper method is to use the wheel-truing diamond in conjunction with an indicator. There is too much spring and wheel wear to work to 0.0002 in. without checking with an indicator. The bearing on which the cutter is rotated when being ground must be true, and the surface on the milling machine against which the cutter is bolted must also run true or else the accuracy in the grinding will be of no value. A good method, when using shell end-milling cutters, is to have an arbor permanently attached to each cutter so that it will be ground on the same arbor as that on which it operates. Cutters should be indicated after being installed on the milling machine.

Cutters with a small number of teeth must be run with comparatively slow feed per revolution of spindle, where a good finish is desired.

FRANCIS S. WALTERS.[9]

TO THE EDITOR:

In answer to the question raised by Mr. Goddard, the problems referred to by us as being different from those encountered in the grinding of high-speed steel cutters were especially those introduced by the extreme hardness of cemented carbides.

As indicated in the paper, new grinding wheels and a new grinding technique had to be developed to permit commercial use

[9] Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

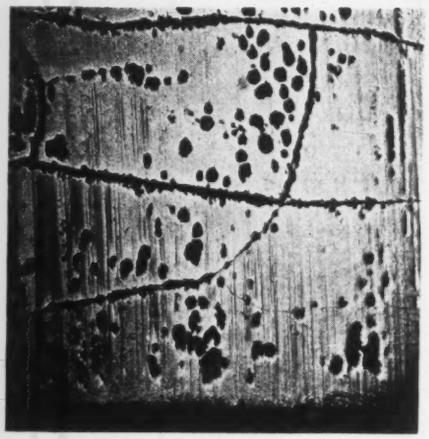


FIG. 1 TYPICAL EXAMPLE OF A CRACKED CEMENTED-CARBIDE TIP CAUSED BY USE OF TOO GREAT DEPTH OF CUT IN GRINDING

of cemented-carbide milling cutters. Although, to some extent, the grinding of high-speed steel cutters presents similar problems to those encountered in the grinding of cemented-carbide cutters, important differences are found. We refer particularly to the special care that must be taken in grinding cemented-carbide cutters to avoid cracking the tip, a problem that, with normal care, does not occur with high-speed steel. With cemented carbides, cracking occurs easily if the depth of cut is only slightly too great. A typical example of a cracked cemented-carbide tip caused by the use of too great a depth of cut when grinding the cutter is shown in the photomicrograph Fig. 1. Furthermore, development of green-grit abrasive and diamond wheels was only due to the need introduced by using cemented-carbide tools.

Naturally, grinding of high-speed steel cutters has also benefited from the improved technique developed for cemented-carbide cutters. An example of this is the increasing use of one main cutting edge on the periphery of a face milling cutter instead of two (see Fig. 4 in the paper). Figs. 2 and 3 are photographs showing chip flow up the face of the tool with one and two main cutting edges respectively. In the latter case considerable crowding of the chip is seen to occur at the junction of the two edges, as the material removed by each edge tends to flow perpendicularly thereto, thus resulting in mutual opposition. This development of a single inclined main cutting edge, with the attendant saving in grinding time, is also applicable to high-speed cutters.

In modern cutter grinders, such as the one illustrated in the paper, the tooth rest can be adjusted so as to abut against either the face or back of the tooth. While supporting the tooth face by the rest will provide the greatest uniformity in cases where the blade thickness varies appreciably, nevertheless, this method requires constant attention on the part of the operator to maintain the tooth in contact with the rest against the grinding force. On the other hand, when the back of the tooth is supported by the rest, the grinding force acts to hold it in place, and in practice the blade thickness is usually found sufficiently uniform, and the back smooth enough, to provide the desired degree of accuracy.

The figures for hardness, commented on by Mr. Longwell, were given only as a rough indication of the great difference in the hardness of high-speed steel and cemented carbides. His observation concerning difficulties attending use of a flow of coolant on cutter grinders, confirms our own experience, as given in the paper. Use of a felt pad to supply the small quantity of coolant required by a diamond wheel is not open to these objections.

His statement that silicon carbide wheels with a grain size finer than 80 are seldom used does not check with com

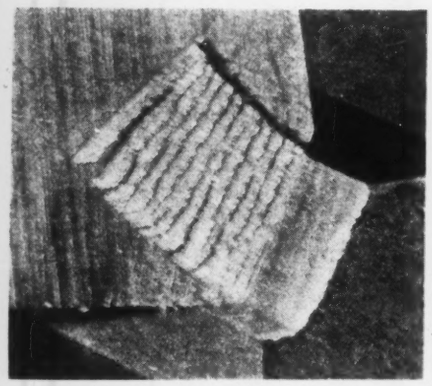


FIG. 2 CHIP FLOW UP THE FACE OF A CUTTER HAVING ONE MAIN CUTTING EDGE

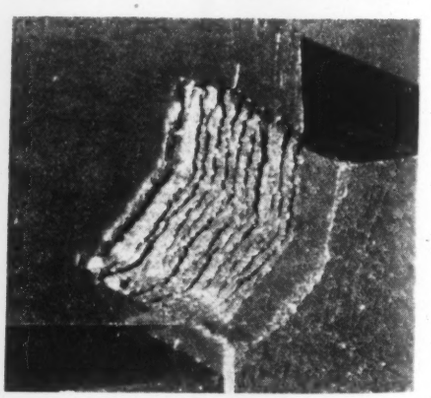


FIG. 3 CHIP FLOW WITH A MILLING CUTTER HAVING TWO MAIN CUTTING EDGES

mercial practice in the sharpening of cemented-carbide milling cutters. Green-grit wheels of 120 grain size are commonly used in large-production shops. Use of a highly developed, fully automatic machine, with compensation for wheel wear and similar factors, is usually justified only where a large number of similar cutters are to be ground on one machine.

The remarks by Mr. Walters, in toto, confirm our statement of a slight advantage in favor of the cup wheel. Where two clearance angles are used, however, as recommended in our paper, with a consequent narrow "land" adjacent to the cutting edge, the effect of the concavity produced by a disk wheel is not of practical importance. While either type of wheel can be used on the machine illustrated in the paper, this is not true for all machines; therefore, selection of cup or disk wheel is often governed by the type of machine used.

In conclusion, we would reemphasize the importance of not permitting cutter wear or breakdown to proceed far before regrinding. Failure to do this will result in great increase in grinding time and unnecessary waste of the cemented carbide.

HANS ERNST.[10]

Power Pooling

TO THE EDITOR:

This paper[11] is an interesting description of an important power system. The Detroit Edison Company, sitting alone in the center of one of the most vital industrial districts of the country, has developed an exclusive and somewhat individualistic system. Every power engineer expects something different, if not extraordinary, in engineering practice from that company.

In speaking of the size and kind of turbines which should be installed when any new power-generating unit is in prospect, the authors seem to have little use for a type of turbine which they define by the cynical name of "sprawling mammoths." I do not like to believe, yet I am inclined to suspect, that this new name is intended to characterize the 200,000-kw unit at the State Line Station of the Chicago District. This has one high-pressure turbine which exhausts into two low-pressure units and doubtless the authors consider it to be the outstanding example of the type. If that cynical name is to be generally adopted it must include all of the installations that are being made this year where a so-called "topping turbine" exhausts into one or more low-pressure units. As this type of turbine combination is becoming popular in the industry, you may be interested in a brief summary of our experience.

In general, use of higher steam pressures contemplates turbines of large size, because the greater the volume of steam going through the high-pressure blading, the better the efficiency. Our "sprawling mammoth" operates at only 650 lb pressure on the high-pressure turbine instead of 1250 lb, which most of the large companies are using today. When the State Line unit was ordered in 1926, 650 lb was still a high pressure, and the saving in efficiency and initial cost per kilowatt of capacity seemed to be enough to warrant the combination unit. The basic idea of this unit grew from the six compound units which were installed from 1924 to 1928 at the Crawford Station, where we pioneered with 600 lb pressure.

The unit went into service in the fall of 1929. One night early in December, before the station was thoroughly broken in, the intake forebay was filled with ice in a sudden and violent storm on Lake Michigan. The warm-water by-pass to the intake had unfortunately not been put in service, and this trouble shut down the whole unit for some hours. That was not the fault of the turbines. The whole plant would have been shut down if it had contained "several turbines of moderate size," instead of a "sprawling mammoth." In the $7\frac{1}{2}$ years since, the unit has never been off the line, and its operating record has been 100 per cent. Each of the three turbines in the combination has been down occasionally for overhaul, and we have had accidents that have tripped out one of the generators but the other two have run on as though they were entirely separate. Just two weeks ago, the generator on the high-pressure turbine tripped out due to a failure of a bushing terminal on a feeder circuit breaker. The two low-pressure turbines automatically picked up their full capacity on high-pressure steam, and the rest of the load that the high-pressure generator lost was taken up by other generators on the interconnected system. No customer was affected. That is just the way this year's crop of "topping turbines" will be expected to act, if the generator on the high-pressure turbine trips off the line.

As the authors say, deciding what is the proper size of generator to install is not an easy matter. Many factors are often involved, and, more often, many different opinions must be reconciled, but most electric-power engineers today have in mind something between 10 and 15 per cent of the maximum load as being about right. However, the past experience of most of the power companies is that the 10 per cent unit of today becomes a 5 per cent unit in not very many years and long before the unit is obsolete. That experience is likely to be repeated in the next few years.

That, after many years' experience with duplicate turbines of "moderate size," the Detroit company is now installing a 75,000-kw unit is interesting. This is just the size of the generator on the high-pressure turbine of the State Line unit. This new 75,000-kw unit is ordered for 815 lb pressure and 900 F total temperature. Inasmuch as boilers, turbines, piping, and valves have now been standardized for 1250-lb pressure, I cannot understand why the Detroit company does not use that pressure. Also, inasmuch as it conducted a long research on high temperatures and papers on that subject seem to indicate that 1000 F is a proper and safe temperature, I had expected a temperature rather higher than that already adopted by several large companies.

The description of the "loose-linked" interconnected system is interesting. This seems to necessitate operating each power station very much as a unit in itself. Transferring any large quantity of energy across the immediate Detroit area from one power station to another does not seem to be practicable. I doubt if a unit out of service at Trenton Channel or Marysville could be satisfactorily supplanted by a spare unit at Connors Creek, for example. If the interconnections were made much stronger, I believe it would be more satisfactory and more economical in the long run.

WILLIAM S. MONROE.[12]

Machine Tools and Automobile Mass Production

TO THE EDITOR:

That the automobile industry has kept machine-tool engineers on their toes is plainly evident from this paper[13] which also demonstrates the fact that today

[10] Research engineer, Cincinnati Milling Machine Company, Cincinnati, Ohio. Mem. A.S.M.E.

[11] "Pooling Power in a Large Industrial Center," by J. W. Parker and R. E. Greene, MECHANICAL ENGINEERING, May, 1937, pp. 335–339.

[12] President, Sargent & Lundy, Inc., Chicago, Ill. Mem. A.S.M.E.

[13] "Machine-Tool Builders' Contributions to Mass Production of Automobiles," by F. W. Cederleaf, MECHANICAL ENGINEERING, June, 1937, pp. 405–408.

cooperation and not competition is the law and life of industry. Emphasis of this concept of business is, to my mind, one of the greatest contributions of the automotive industry to all manufacturing.

Gradual but constant refinements and improvements sought and accomplished in the automotive industry, with similar effect upon contributing industries, will bear repeating. Concentrated consideration of new engineering possibilities under constant and high-pressure thought, if released as rapidly as conceived, would lead to scrapping present machines, methods, and plants so rapidly as to cause economic chaos, which resulted in too many instances with the sudden ceasing of the World War. Monuments to that fallacy are still in evidence to the sorrow of many.

The time element not only to produce but also maintain in daily production closer tolerances and interchangeable parts is well emphasized, and, with it, the necessity of cooperation from many contributing manufacturers. No more patent illustration is possible of the absolute fact that we cannot run our business alone. Willingly or unwillingly, we must cooperate if we are to stay in the picture today. This ceaseless, compelling, irrepressible, forward march of the industries, with its constant challenge to man's ingenuity and accomplishment, with its adventure, its daring, its romance, cannot but make every one of us tingle with pride and the urge to greater accomplishment in the further easing of human toil and increasing the means of contributing to human happiness.

A. N. GODDARD.[14]

TO THE EDITOR:

Mr. Cederleaf has presented a paper which clearly pictures the developments made by the machine-tool builders in aiding the art of building automobiles along mass-production lines. That the carbide tool has played no small part in the success of the precision-boring operations, which he says have been carried on at surface speeds of 400 fpm, is apparent.

One line of development that the machine-tool builder has contributed to the successful application of carbide tools was not mentioned. I refer to the carbide-tool grinding machines as these have played an important part in enabling the carbide tools to be ground accurately to correct shapes and cutting edges.

[14] President, Goddard & Goddard Co., Detroit, Mich. Mem. A.S.M.E.

Successful application of carbide tools has not been confined to the new machine tools. Actually, they have been used in large numbers to reduce costs, improve the quality of the finish, and hold closer tolerances on old as well as new machines. In doing this work, surface speeds of 400 fpm are not always used. High speeds, which are used in precision boring, are made possible by using special grades of carbide tools that have been developed for this work. These special carbides present a cutting edge that resists abrasion and, therefore, allows the work to be finished to close tolerances and with fine surface finishes. However, on other applications in automobile factories, carbide tools are commonly used on many different operations and at slower speeds and greater feeds on continuous and interrupted cuts.

One particularly interesting point in the paper illustrated the imagination or possibly vision of Mr. Cederleaf when he stated that the future might see carbide tools used at 400 fpm and $^3/_{16}$-in. feed in the finishing of cylinder bores. Maybe this is not beyond the realm of possibility, and, in the same spirit, I would like to suggest that using a revolving broach, which is either pushed or drawn through the cylinder holes at even greater feeds, may also be possible and that possibly final finishing of the bore may ultimately be done with carboloy burnishing bars.

As a suggestion, it may be possible to improve the methods of holding carbide tools in the machines so that tool changes could be made more quickly and accurately. Only recently, I observed a production machine in operation where two tools were used in finishing a surface that had to be held within a total tolerance of 0.0015 in. on the diameter. On this particular machine, both tools could be changed and it could again be in production in 2 min 15 sec and still maintain an accuracy without tool adjustment within 0.0005 to 0.001 in. on the diameter. With such tool setups, the number of pieces per grind is of little importance and carbide grades can be selected which will allow machining time to be reduced to the minimum.

JAMES R. LONGWELL [15]

A Correction

On page 628 of the August issue the expression "$\log_{10}$" in Equations [9] and [10] should be within the parentheses instead of outside as printed.

[15] Chief engineer, Carboloy Company, Inc., Detroit, Mich

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of an interpretation of this Committee formulated at meeting of the Executive Committee on July 28, 1937, and approved by the Council.

Inquiry: For dry-ice converters, is it mandatory that the rules of the code in Pars. U-140 to U-144, inclusive, be applied if the cycle of operation is such that the maximum allowable working pressure cannot occur when the vessel is at the minimum temperature?

Reply: The rules in Pars. U-140 to U-144, inclusive, requiring that impact tests be made, permit seamless vessels of special construction to be operated with a factor of safety of 4. Pending a more complete investigation of this subject, and if the cycle of operation in these vessels is such that the maximum allowable working pressure cannot occur when the vessel is at the minimum temperature, it is the opinion of the committee that vessels to be used as dry-ice converters may be built with a factor of safety of 5 in accordance with the other rules of the Code for Unfired Pressure Vessels, which do not require impact tests.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

The Renaissance of Physics

THE RENAISSANCE OF PHYSICS. By Karl K. Darrow. The Macmillan Company, New York, 1937. Cloth, $5^3/_4 \times 8^1/_2$ in., 306 pp., 44 figs., $3.

REVIEWED BY J. ORMONDROYD[1]

SOME eighty or ninety years ago the ideas and concepts which are the tools of mechanical engineers today ceased to make front-page news. Perhaps they did not make news even then; since science editors are the products of our own times. The mechanical conception of the universe which was launched so brilliantly by Galileo in the early seventeenth century and given a definitive program and goal by Newton less than a century later, seemed to have exhausted its driving force in the nineteenth century after it had produced the thermodynamical theories.

The last high priest of the classical physicists, Kelvin, saw the twentieth century dawning with misgivings. The early portents of that age that we can call a scientific renaissance presaged for him scientific ruin and chaos. Even the chemists and electricians of the nineteenth century understood their sciences by means of mechanical models; and like Alexander, looking abroad, they saw no new worlds to conquer.

If physics was to remain the field of spectacular, important activity, it needed new fields and concepts. When the electron was freed from matter the physicists found fresh pastures in the microscopic world. And in the macroscopic world Einstein opened up new vistas. Our own century with its quantum and relativity theories gave physics a new lease on vigorous living and for some forty years the activity has been so explosive and ebullient that Dr. Darrow may well call this age the Renaissance of Physics. Today the leading physical concepts are electrical and not mechanical. The mechanical engineer may feel more at home intellectually in the age of Galileo and Newton than he does in the age of Planck and Einstein.

Many minds have taken up the task of explaining and expounding the new physical outlook. The details of the mathematical theories which tie the new ideas together have been set forth with simplifications in popular works; but these attempts are doomed to general failure since so few, even in the engineering professions, have learned to read the "language of size" with any facility. The implications of the new physics are so strange and far-reaching that the philosophical aspects of the new outlook have not lacked expositors. But these, waxing more metaphysical as they unfold their tale, overawe us with mysticism. They begin in physics and end in religion—proclaiming new gods who are mathematicians.

Both the mathematical and philosophical methods of popular presentation are premature at the present time. Before the mind can understand the interconnections and implications of a large group of facts it must know first what the facts are.

Among all the popular treatises of the day, "The Renaissance of Physics" is remarkable in that it is strictly limited to statements of historical and observational facts in the realm of atomic physics. All but two of the results of relativistic physics are excluded from the pages of this book—the relationships between mass and velocity and the equivalence of mass and energy are important relativistic concepts which must, of course, be alluded to in any discussion of modern atomic physics. Dr. Darrow has emphasized Who, What, When, and Where and wisely limited Why to the simplest cases. He realizes that he is writing for a nation of practical men; men who are ignorant and proud of it—for a nation in which Brain Trust and Highbrow are not yet general terms of praise.

To those who may be bewildered in attempting to adjust nineteenth-century minds (or in the case of mechanical engineers, seventeenth-century minds) to twentieth-century physics, Dr. Darrow's first chapter on "Physics and the Physicist" will offer much enlightenment and comfort. The new outlook is not something different in kind from the old, it grew naturally out of the old and it is a luxuriant extension of the old. It makes use of the same measuring instruments, the same modes of thinking as the old and when it operates in fields formerly cultivated by classical physicists it arrives at much the same conclusions. The new physicist is not a metaphysician, nor is he a magician, neither is he a priest of a new and esoteric religion. A physicist is still as he always was "someone who uses his senses for observing; mechanical and thermal instruments for measuring and mathematics for reasoning." After this reassuring chapter the reader can push on into the real subject matter of the book with some feeling of confidence that the old landmarks will not recede from sight too rapidly.

First a broad outline of classical electrostatics is given. Lightning, charged amber, St. Elmo's fire, and electric eels were the disjointed and apparently unrelated signs of electricity known to the ancients. Gilbert, in the late sixteenth century made the first steps toward the correlation and extension of these facts. Franklin with his kite and key in old Philadelphia still further advanced this correlation by proving that lightning was the same as other electric discharges from rubbed bodies. Finally as the twentieth century approached, the electron was set free from matter in such a way that it could be studied by itself in an isolated and controlled situation. Ordinary matter which gives no hints of its essential electrical nature is made of particles internally in electric equilibrium. Charged bodies are those in which this equilibrium has been upset.

The author takes a whole chapter to discuss the history and facts concerning the electrons which are released from matter. When they come out into the open they lead a separate independent existence and produce effects, during their moments of freedom, which we can see and measure. The vacuum is the playground in which the free electron is most readily studied. The most peculiar episode recounted in this chapter relates to Edison's discovery of the evaporation of electrons from heated conductors in a vacuum. This, perhaps the most important single discovery of Edison in all his long inventive career, was neglected by the Wizard. Other men took it up,

[1] Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich. Mem. A.S.M.E.

described it accurately, and initiated the age of radio tubes.

The quantitative measurement of the velocity, mass, and charge of the free electron is the next subject treated extensively both historically and factually.

The correlation between magnetism and electrons in motion is discussed in chapter 5.

Even casual readers of scientific news have heard of the Wilson Cloud Chamber and have, at least, a vague idea that it is an important device in the strange activities of modern physicists. This simple instrument is described in chapter 6, its operation and results are outlined. Atoms and electrons serving as nuclei of condensation in the Wilson Cloud Chamber leave visible tracks in the low-pressure vapors in the chamber which can be observed and photographed. By the use of magnetic fields these tracks may be made to bend in ways which tell the physicist much about the electric characteristics of the moving particles.

The dual nature of light as a wave phenomenon and a corpuscular phenomenon is one of the strangest chapters in modern physics and Dr. Darrow gives a clear description of the facts which force this duality upon us in his next chapter.

The grand finale of the activities of the new physicists is a clear conception of the structure of the atom and the finally realized possibility of the transmutation of the elements. The cyclotron, the high-voltage electrostatic generator, and "heavy water," all familiar as names to newspaper readers in the last five years, play important rôles in this achievement. Dr. Darrow changes these names into realities by clear and simple description. The alchemist's dream at last comes true—but not in the way the alchemist naively wanted it to. So far no gold has been produced by modern alchemists which does not cost far more than gold produced by uncoerced nature; but transmutation leads near to that more valuable goal of understanding the structure of our universe.

If transmutation of the elements is the crowning achievement of modern physics then, according to Dr. Darrow, the jewel in that crown is the transmutation of light into electricity. Photons of light may vanish and produce electrons of matter where they disappeared and the reversed process may also be achieved.

Dr. Darrow's final peroration sums up the whole grand achievement of atomic physics as a "unification of nature." Each great advance in science is a synthesis of ideas and facts which grow up separately and in an apparently unrelated fashion. Our present view of nature is this: "No element, nor matter itself, nor light is permanent. All that is perpetual is energy." The grand generalizations of classical physics were two—the Conservation of Matter *and* the Conservation of Energy. These have been unified into the more general principle enunciated above. Other ages than our own may have surpassed us in the creations of music, the plastic arts, religion, or literature but ours is the great age of science. "Atomic theories existed long ago, but ours is the generation which, first of all in history, has seen the atom. The belief that all things are made of a single substance is old as thought itself, but ours is the generation which, first of all in history, is able to receive the unity of Nature not as a baseless dogma but as a proven principle."

Dr. Darrow's style is clear, the book reads easily. The author uses vivid imagery to stimulate the reader's grasp of his ideas. No better book has yet been written to give mechanical engineers a clear picture of the essentially electrical universe in which they live.

Books Received in Library

ABWASSERFACHGRUPPE DER DEUTSCHEN GESELLSCHAFT FÜR BAUWESEN e.V. Anweisung zur Auswertung von Schreibregenmesseraufzeichnungen für wasserwirtschaftliche Zwecke, A.A.R., 1936 (Sonderdruck aus "Gesundheits-Ingenieur" 60, 1937). Deutsche Gesellschaft für Bauwesen, Berlin. Paper, 8 × 12 in., 20 pp., diagrams, charts, tables, 1 rm. A manual of advice upon the evaluation of rainfall data for such technical purposes as water supply, power development, etc.

BRIDGES IN HISTORY AND LEGEND. By W. J. Watson and S. R. Watson, illus. by E. M. Watson. J. H. Jansen, Cleveland, Ohio, 1937. Cloth, 8 × 11 in., 248 pp., illus., $3.50. This attractive volume brings together a large amount of interesting information about bridges, historical and legendary. Rainbow bridges, devils' and saints' bridges, war bridges, and peace bridges are discussed with much quotation from historians and poets. There are chapters upon bridge pageants, old London bridge, covered bridges, and toll bridges, and upon famous bridge builders. The book is illustrated with pen-and-ink drawings.

DEUTSCHES MUSEUM ABHANDLUNGEN UND BERICHTE, Jg. 9, Heft 2, 1937. BAU und ENTWICKLUNG des ERDBALLS. By H. Lorenz. V.D.I. Verlag, Berlin, 1937. Paper, 6 × 8 in., 56 pp., 0.90 rm. In this pamphlet an engineer, formerly professor of physics at Halle University, discusses the structure and evolution of the earth in simple, readable language. The results of recent investigations are combined into a systematic account which clarifies many matters.

END OF TRACK. By J. H. Kyner, as told to H. Daniel. Caxton Printers, Caldwell, Idaho, 1937. Cloth, 7 × 10 in., 277 pp., illus., $3. Reminiscences of a pioneer railroad builder, whose activities were a part of an historically significant period in the development of the West. The autobiographical material covers boyhood years, the Civil War, and his experiences as a railroad builder, chiefly in Nebraska, Idaho, Colorado, and Wyoming.

GREAT BRITAIN. AIR MINISTRY, Aeronautical Research Committee. Report for the years 1935 and 1936. His Majesty's Stationery Office, London, 1937. Paper, 9 × 12 in., 60 pp., illus., charts, tables (obtainable from British Library of Information, 270 Madison Ave., New York, $1.20). In addition to the report of the Committee, this publication includes reports of subcommittees upon aerodynamics, fluid motion, structures, engines, and other topics.

INTRODUCTION TO FERROMAGNETISM. By F. Bitter. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 314 pp., illus., diagrams, charts, tables, $4. Here are defined the problems whose solution may be expected to reveal the fundamental processes which constitute ferromagnetism. Magnetic, mechanical, and electrical phenomena are discussed. The tendency is toward a consideration of the subject from the point of view of solid solutions rather than of homogeneous pure substances.

KUNST- UND PRESSTOFFE 2 (Verein deutscher Ingenieure). V.D.I. Verlag, Berlin, 1937. Paper, 8 × 12 in., 38 pp., illus., diagrams, charts, tables, 2.75 rm. This annual contains nine papers upon the use of synthetic plastics, and the standards adopted for shaping and using them. The topics discussed include the structure of plastics, their physical, mechanical, and thermal properties, and their suitability as bearings.

MACHINE DESIGN. By P. H. Hyland and J. B. Kommers. Second edition. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 598 pp., illus., diagrams, charts, tables, $4.50. A comprehensive elementary textbook on machine design, arranged to be studied simultaneously with mechanics-of-materials courses. It covers fundamental movements and joints, metalworking, and various specific machine elements.

MACHINE TOOL OPERATION. Part 2. By H. D. Burghardt. McGraw-Hill Book Co., New York and London, 1937. Cloth, 5 × 8 in., 512 pp., illus., diagrams, charts, tables, $2.75. This book is intended as a text for apprentices and young machinists. It aims to present the fundamental principles of the construction and operation of the drilling machine, shaper, planer, milling machine, and grinding machine, and so to build a foundation for rapid operation. This edition has been revised and enlarged, and a chapter on hydraulic power transmissions added.

MANUEL DE LA COKERIE MODERNE. By M. Simonovitch. H. Vaillant-Carmanne, Liége, Belgium, 1937. Cloth, 7 × 11 in., 750 pp., illus., diagrams, charts, tables, 740 fr. belges. This treatise on coke making is based upon the two well-known works of the late Dr. Wilhelm Gluud, the Handbuch der Kokerei and the International Handbook of the By-Product Coke Industry. These books have, however, been entirely rearranged for the present work and completed and brought up to date. This volume of the work, the first, provides a comprehensive account of the occur-

rence, composition, and properties of coals and coke-oven refractories, the preparation of coals for coking, briquetting, coke ovens, and equipment.

METAL-PLATE WORK, Its Patterns and Their Geometry. Two Vols. By C. T. Millis. Sixth edition. E. & F. N. Spon, London; Chemical Publishing Co., New York, 1937. Cloth, 5 × 8 in., 539 pp., diagrams, charts, tables, $4.60. This manual on laying out sheet-metal work has been in use for 50 years. The present edition follows the established lines but has been revised and equipped with more problems. It has also been divided into two volumes. The first forms a complete elementary course; the second an advanced one, in which is included a number of mensuration problems.

OIL BURNERS. By K. Steiner. New York and London, McGraw-Hill Book Co., 1937. Cloth, 7 × 10 in., 436 pp., illus., diagrams, charts, tables, figures, $4.50. A complete treatise on oil-burner practice, embracing discussion of fundamental and advanced engineering and practical methods of oil-burner design, construction, installation, operation, and maintenance. Covers the characteristics, specifications, combustion, and handling of fuel oils, and considers domestic, commercial, and industrial applications. Useful tables are contained in an appendix.

OIL FUELS AND BURNERS. By J. A. Moyer. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 375 pp., illus., diagrams, charts, tables, $4. An information manual which covers the general subject of oil fuels and burners with special reference to automatic domestic types. Includes charts and diagrams for system layouts, and material on automatic control devices, trouble charts, heating-requirement calculations, and heat insulation.

PRACTICAL DIE DESIGN AND DIE MAKING. By E. G. Marshall. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 144 pp., diagrams, $2. A presentation of tested methods of die designing and diemaking, expressed as fully as possible in shop terms for the use of the average worker in the field. Covers all types of dies.

(The) SCIENCE OF VALUATION AND DEPRECIATION. By E. B. Kurtz. Ronald Press Co., New York, 1937. Cloth, 6 × 9 in., 221 pp., diagrams, charts, tables, $4.50. This book offers scientific solutions, based on life-experience tables, to basic problems in valuation and depreciation estimating and accounting. Profusely illustrated by graphs, tables, charts, etc. The advocated methods are compared with those in general use.

SELECTED WRITINGS OF ABRAM S. HEWITT. Edited by A. Nevins, with introduction by N. M. Butler. Columbia University Press, New York, 1937. Cloth, 6 × 10 in., 414 pp., illus., tables, $3.50. In addition to being the foremost ironmaster of his generation, Abram S. Hewitt (1822–1903) was an important figure in politics and government, and in the field of education. The present volume contains a selection from his writings, illustrative of his activities in all these fields. Of particular interest to engineers are those upon the production of iron and steel in its social and economic relations, American mining and metallurgy, iron and labor, Sir Henry Bessemer, and the relations of capital and labor.

SOUND. By A. T. Jones. D. Van Nostrand Co., New York, 1937. Cloth, 6 × 9 in., 450 pp., figures, tables, diagrams, charts, tables, $3.75. An elementary book on sound. Fundamental information is presented with historical interpolations. The subjects of sound production and transmission, free and forced vibrations, musical scales and instruments, speech and hearing are considered with their modern technical applications. Review questions are inserted at intervals and certain special points are covered in appendixes.

TECHNOLOGIE DER ZINKLEGIERUNGEN. (Reine und angewandte Metallkunde in Einzeldarstellungen, edited by W. Köster.) by A. Burkhardt. Julius Springer, Berlin, 1937. Cloth and paper, 6 × 9 in., 256 pp., illus., diagrams, charts, tables; cloth, 31.50 rm.; paper, 30 rm. This volume aims to provide a comprehensive account of the properties and uses of zinc alloys. The important binary and ternary alloys are described, and the important technical alloys discussed. Two thirds of the book is devoted to melting and casting, extrusion, stamping, rolling and other methods of working, to welding and riveting, and to surface treatment.

TEXTBOOK OF THERMODYNAMICS. By P. S. Epstein. John Wiley & Sons, New York, 1937. Cloth, 6 × 10 in., 406 pp., diagrams, charts, tables, $5. Thermodynamics is treated from the physicist's point of view, and mainly as apart from statistical mechanics. Part of the book is intended as a basic text for advanced students, the remainder presents material of use in special courses.

THEORY AND PERFORMANCE OF AXIAL-FLOW FANS. By C. Keller, L. S. Marks, and J. R. Weske. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 140 pp., illus., diagrams, charts, tables, $4. A presentation of those parts of a German dissertation on airfoil theory as applied to the design of axial-flow fans which appear to be of value to designers. The most important section of the book is chapter 4, giving performance data of a series of axial-flow fans.

THOMAS' REGISTER OF AMERICAN MANUFACTURERS. Twenty-seventh edition. 1937. Thomas Publishing Co., New York. Cloth, 9 × 12 in., illus., $15 ($10 to former subscribers). This standard directory is so widely and favorably known that extended notice is unnecessary. As usual, it contains carefully classified and indexed lists of manufacturers of all kinds; lists of banks, boards of trade, and other commercial organizations, trade papers, leading manufacturers, and trade names.

V.D.I.-FORSCHUNGSHEFT 384, May–June, 1937. WIRBELBILDUNG UND KRÄFTEWIRKUNG AN UMLAUFENDEN KREISELRADSCHAUFELN, by E. Frietsch. V.D.I. Verlag, Berlin, 1937. Paper, 6 × 12 in., 28 pp. illus., diagrams, charts, tables, 5 rm. This report on the eddies and forces on turbine blades presents the results of an extended study at the Karlsruhe Institute for Flow Investigations, undertaken to throw light upon the relations between fluid motion and power conversion. The report includes an interesting series of photographs showing the behavior of various types of turbine blades.

V.D.I.-FORSCHUNGSHEFT 385, July-August, 1937. Grundlagen der Wassermessung mit den hydrometrischen Flügal, by W. Henn. V.D.I. Verlag, Berlin, 1937. Paper, 6 × 12, 22 pp., illus., diagrams, charts, tables, 5 rm. A report upon an investigation of the screw-type current meter, carried out in the Hydraulic Laboratory of the Dresden Technical High School. The theory of the meter, its calibration and the determination of its hydrometric constants are discussed, as well as its design and construction. Its reliability for stream gaging is considered. A bibliography is included.

V.D.I.-SONDERHEFT. NEUZEITLICHE KAMPFSCHIFFE. Verein deutscher Ingenieure, Berlin, 1937. Paper, 8 × 12 in., 40 pp., illus., diagrams, tables, paper, 3.75 rm. During the years 1936 and 1937, five articles appeared in the *V.D.I. Zeitschrift* which described the development of some important types of fighting ships since the World War. These articles, by W. Hadeler, are here made available in one pamphlet. They give a general survey of development and contain tables of data upon modern vessels of all navies except that of Germany.

WEATHER ELEMENTS. By T. A. Blair. Prentice-Hall, Inc., New York, 1937. Cloth, 6 × 9 in., 401 pp., illus., diagrams, charts, maps, tables, $5. An introductory text which aims to set forth the facts and principles concerning the behavior and responses of the atmosphere in such a way that the reader will understand the physical processes underlying observed weather phenomena, and to present general information about the weather and our knowledge concerning it. Instruments and methods for weather observation are described and such subjects as climate and its importance to man, and world weather relations are discussed.

WHO'S WHO IN ENGINEERING, a Biographical Dictionary of the Engineering Profession. Fourth edition, 1937. Edited by W. S. Downs. Lewis Historical Publishing Co., New York, 1937. Cloth, 6 × 10 in., 1638 pp., $10. This volume contains brief professional biographies of the leading professional engineers of America, based upon information supplied personally and therefore authoritative. Twelve thousand engineers are included, 14 per cent more than in the previous edition, and all biographies have been revised and brought up to date. A geographical index is included.

WORLD OF ATOMS. By A. Haas. Second, edition, enlarged and revised, translated by G. B. Welch and H. S. Uhler. D. Van Nostrand Co., New York, 1937. Cloth, 6 × 9 in., 183 pp., illus., diagrams, charts, tables, $3. A translation of the revision of a series of lectures intended to present to a lay public the achievements of modern atomic physics in as brief and yet thorough a manner as possible. Given a sufficiently general education the lay reader should be able to progress with understanding from the beginning fundamental information to the concluding more involved discussions.

YEAR BOOK ON COAL MINE MECHANIZATION. American Mining Congress, Washington, D. C., 1936. Leather, 6 × 9 in., 362 pp., illus., diagrams, charts, tables, $2. The first section of this year book contains extracts from the reports of various district committees discussing practice in the treatment of cutting bits, in testing mine fans, in systems of mining, in underground power distribution, conveyor mining, and other subjects. The remainder of the volume is given to papers presented at the 1936 convention.

THIS MONTH'S PAPERS *and* AUTHORS

THIS MONTH A. R. STEVENSON, JR., and E. E. PARKER turn their attention to the electrical-manufacturing industries and present a convincing array of examples of the kind of work men with mechanical-engineering training are called upon to do. It is not necessary to belittle the work of specialists in many fields to point out that plant operation and maintenance, design of machinery, tools, and methods, and the manufacturing problem itself in the normal plant, regardless of its product, must call for the services of men trained and competent in mechanical engineering. One benefit that should follow from this article should be an awakening of the realization in the minds of young men getting ready to enter engineering careers of the fact that opportunities for mechanical engineers are to be found in industries whose names create the impression that they are reserved for specialists in some branch of the sciences.

After all, why worry too much about kinds of engineering? Mr. Stevenson holds a degree of C.E. from Princeton and of M.S. and Ph.D. in electrical engineering from Union. He has worked in the power-and-mining engineering department of the General Electric Company, made the preliminary studies that led to the company's entry into the household-refrigeration field, helped to establish the G.E. advanced course in engineering, and now is assistant to the vice-president in charge of engineering and is following the development of air conditioning. Mr. Parker, a more recent graduate from a more distant college (Oregon State in 1931) holds a B.S. in mechanical engineering), is a product of G.E. training courses, in which he has also served in a supervisory capacity, has been assigned to the general engineering department, and now is in the control section of the turbine department.

THE WHIRLING MACHINE

Although Samuel Pierpont Langley suffered cruelly from the ridicule and ingratitude heaped upon him by an ignorant public, his name is still honored today for his exploration of the infrared portions of the spectrum and for his researches in aeronautics. Such men as the late Henry Adams, keen student of the trend of history of human thought, sought him out. An aging scientist at the turn of the twentieth century when science suffered so profound a revolution, his mind and imagination were too far in advance of the progress of technology to benefit from some of the contributions which might have made the aerodrome a greater success. His was the patient method of scientific research, and the whirling table, constructed at the Allegheny Observatory, was one of the devices with which he explored the field of aerodynamics. In a brief article in this issue, Prof. JOHN A. DENT, of the University of Pittsburgh, illustrates and describes a recently constructed model of the whirling table, built by one of Langley's former workmen, and now on display at the University.

WELDING AS A MACHINE-SHOP OPERATION

At Erie, Pa., shortly after this issue is in the mails, the Machine Shop Practice Division of The American Society of Mechanical Engineers at the Society's 1937 Fall Meeting, will be discussing welding as a machine-shop operation. Two of the papers here to be presented are published in this issue. They offer impressive testimony to the fact that welding has become a machine-shop operation of prime importance and extraordinary usefulness and economy. What this relatively new technique means to works organization and methods is set forth by A. G. COCHRANE in a paper entitled "Arc-Welding Practice in the Machine Shop." A. P. WOOD emphasizes the economy feature in a paper entitled "Better Electrical Apparatus with Minimum Welding." Both Messrs. Cochrane and Wood are with the General Electric Company at its Schenectady plant. Mr. Cochrane came up through the shop, having had a wide variety of experience and training. Today he is superintendent of the arc-weld and general screw-machine department. Mr. Wood, a 1904 Purdue graduate with an E.E. degree, has been with the company since graduation, testing at Fort Wayne, taking the test course at Schenectady, and for several years in the alternating-current engineering department. He is now consulting engineer, motor and generator engineering department.

A SIMPLE HYDRAULIC DYNAMOMETER

Baron Prony's dynamometer has been modified by several inventors, Poncelet, Appold, Lord Kelvin, and James Thomson, for example, and the so-called water-brake, invented by W. Froude and developed by Prof. Osborne Reynolds, substituted hydraulic for mechanical friction in this useful device. A recent type, said to be simplicity itself, cheap and easy for any shop to make, yet possessing desirable operating characteristics, is described in a paper to be presented at the A.S.M.E. Fall Meeting, Erie, Pa., in October. E. P. CULVER, the author of the paper, "Investigation of a Simple Form of Hydraulic Dynamometer," is a Union College graduate, and now an associate professor in the School of Engineering at Princeton University.

AIR CONDITIONING OFFICES AND RESIDENCES

Although air conditioning involves simultaneous and independent control of temperature, humidity, and air movement, summer conditions can be appreciably improved by using furnace- and attic-ventilating fans for "comfort cooling." Several experimental installations of attic fans and tests of furnace fans have been made by The Detroit Edison Company since 1932, and experience acquired with this program of research and experimental work serves principally as the basis for the paper, "Residence and Small-Office Air Conditioning," by G. B. HELMRICH, who has been active in this work. Mr. Helmrich, who holds the degrees of B.M.E. and M.E. from the University of Michigan, and who is a member of the A.S.M.E., started his engineering career with The Detroit Edison Co. Following an interval of 10 years spent in engineering education at the University of Oklahoma, Mr. Helmrich returned to The Detroit Edison Company in 1927, where he is now a mechanical engineer.

INTERCHANGEABLE MANUFACTURE

Back of the astounding productivity of modern mass production lies the principle of interchangeability in manufacture, generally associated with the name of Eli Whitney and government arms contracts. What consequences have flowed from the successful introduction of this principle into the later stages of the industrial revolution and their effects on all departments of human affairs have, perhaps, never been adequately or exhaustively traced, but the history of the early stages of this remarkable development is briefly told in the paper by J. W. ROE, entitled "Interchangeable Manufacture," published this month. To every mechanical engineer this story should be familiar. None but the youngest readers need introduction to Professor Roe who has lived many years in Eli Whitney's city and who is an authority on early machine-tool builders.

PRINTING FROM RUBBER PLATES

While most printing is done from metal type or plates, other materials have been tried from time to time. Thus for certain stocks and surfaces that ordinarily will not give satisfactory results with metal plates, rubber plates can be used. In an article entitled "Rubber Plates and Graphic Arts," by J. B. SHAUGHNESSY, of the Rubber Printing Products Division, American Wringer Company, Inc., Woonsocket, R. I., tells about some of the problems met with in developing this printing technique and how they have been attacked.

MODELS USED FOR RESEARCH

One of the courageous but expensive habits of George Westinghouse was trying things out with full-scale apparatus. If they worked, so much the better, but if they didn't, they made the scrap heap bigger. Model testing is a cheaper, surer, and more scientific method, made popular by aerodynamic and hydrodynamic research and used for all sorts of design problems including those relating to structures. Translation of small-scale into full-scale values is accomplished by applying the laws of similarity. Instruments for conducting model research have been ingeniously devised and in determining the dynamic properties of structures, such as R. K. BERNHARD writes about in this issue, an oscillator was used to impress vertical forces of pure sine form on model structures, and a deflectometer was arranged to record the vibrations. Dr. Bernhard, who is at present employed as consulting and research engineer with the Baldwin-Southwark Corporation, Philadelphia, has spent most of his career in this country and Germany in the design of bridges. As chief engineer of bridges for the German National Railways from 1927 to 1936, he specialized in vibration research and X-ray investigations of welded structures.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Special Group of Heat-Transfer Papers to Be Presented at A.S.M.E. Annual Meeting, in New York, Dec. 6–10

Heat-Transfer Rates and Flow Resistance to Be Discussed

THE PRACTICAL importance of cross-swept tube banks is probably as great as that of any other unit designed for heat transfer, and may be judged by the extent and variety of their applications in equipment of power plants and industrial processes. However, few data are generally available on heat transfer and flow resistance—pressure drop or draft loss—in such equipment. Most of those which are found in the literature are unconfirmed by check tests and their application to commercial equipment involves the use of formulations of which the general validity or limitations have not been established.

New Experimental Results

For this reason, designers and users of heat-transfer equipment will welcome the new experimental results on a large number of arrangements of tubes in banks which are reported in three papers to appear in the October, 1937, issue of the A.S.M.E. Transactions. Results of experimental measurements of heat transfer and pressure drop in 38 different arrangements of tubes in cross-flow, air-swept banks, are fully reported, together with descriptions of experimental apparatus and procedure. Most of the data are from tests of 0.3-in. diameter tubes, but these are checked by tests of several similar arrangements, using tubes of $^1/_2$, $^{11}/_{16}$, and 2 in. diameter, conducted by a second investigator, who worked independently in a different place. Three different conditions of heat transfer were employed.

The experimental results are critically examined and correlated, and are found to be in general agreement with partial data of earlier investigators, with a few exceptions. Comparisons are made with field-test data on commercial equipment, with satisfactory agreement. Several important general conclusions are reached, among them the following:

(*a*) Small-scale or model tube banks yield results that are applicable to full-scale ones, if properly interpreted, and methods of application are outlined.

(*b*) Variations in tube size and spacing in terms of tube diameter have substantial effects in some cases and not in others.

(*c*) There is no consistent general relation between thermal conductance and pressure drop.

These reports will be presented for discussion at the Annual Meeting of the A.S.M.E. in December, in a session sponsored by the Heat-Transfer Committee. This committee was organized a few years ago to encourage efforts to develop methods of calculating effects of heat transfer that give results in agreement with observations in service operation, applicable to all classes of apparatus and service conditions.

Data Applicable to Wide Variety of Equipment

These papers illustrate the merits of this objective, as the data are applicable to a wide variety of equipment and fluids, in contrast with empiric relations of very limited scope. Water tubes of steam boilers, their superheaters, economizers, and some air heaters, are examples of tube banks with transverse gas flow. Others are found in coolers and heaters for air and other gases, at any pressure, including air dehumidifiers, some humidifiers or evaporative water coolers, and air-cooled condensers of steam and other vapors such as refrigerants. Liquids may sweep banks of tubes transversely as well as gases, in heat exchangers for example, and as the rational formulations apply to any fluids of known physical properties, the results obtained with a gas as a fluid are applicable to a liquid.

In view of the wide utility of the data, full discussion of these papers is desirable and is invited, when they are presented at the Annual Meeting. Discussion may add much material of value to that included in the reports. The Committee has made these papers available for publication well in advance of the meeting to afford ample time for detailed study by those who are interested.

The October issue of the A.S.M.E. Transactions in which the papers are to be published will be in the mails on October 11.

C. E. Lucke.[1]

Dates and Places for the 1937 Group Conferences

THE following are the dates and locations for the 1937 Local Sections' group conferences which precede the Annual Meeting of the A.S.M.E. at which matters of Society policy are discussed.

Group I, Hartford, Conn., Oct. 15–16
Group II, New York, N. Y., Oct. 25
Group III, State College, Pa., Oct. 30–31
Group IV, Knoxville, Tenn., Oct. 22–23
Group V, Columbus, Ohio, Oct. 15–16
Group VI, Minneapolis, Minn., Oct. 30–31
Group VII, Denver, Colo., Oct. 23–24

A.S.M.E. Machine Shop Division to Meet With A.W.S.

THE Machine Shop Practice Division of the A.S.M.E. will hold a joint meeting with the American Welding Society on October 19 as a part of the National Metals Congress being held in Atlantic City, N. J.

Papers assigned to this session are:

"Resistance Welding Fabrication," by J. M. Cooper, General Electric Company

"Developments in Large Welded Structures," by C. C. Brinton, Westinghouse Electric & Manufacturing Co.

"Recent Developments in Fusion Welding, by C. W. Obert, consulting engineer, Union Carbide and Carbon Company

J. W. Sheffer has been invited to act as chairman of the meeting. Headquarters will be at the Hotel Traymore where convention rates will be in effect.

Mechanical Catalog Out

1937–1938 Edition Now Being Distributed

THE twenty-seventh annual Mechanical Catalog, 1937–1938 edition, was published on October 1 by The American Society of Mechanical Engineers. Continued improvement in the contents both in volume and scope, should make the Catalog a valuable service.

The Catalog has three sections: (1) "Catalogs of Industrial Equipment, Materials, and Supplies," arranged alphabetically by names of companies, contains illustrated descriptions of the products manufactured by the companies advertising in the book; (2) "Classified Index to Manufacturers" contains the names of over 850 firms, and lists under some 5000 classifications thousands of items used by industry; (3) "Manufacturers List," an alphabetical list

[1] Professor of Mechanical Engineering, Columbia University, New York, N. Y. Member of A.S.M.E. Heat-Transfer Committee.

of firms included in this issue, gives addresses and general line of manufacture.

Incorporated in the Catalog this year is a listing and description of many codes, standards, and publications of the A.S.M.E. or sponsored by the A.S.M.E. This feature, it is believed, will be a great convenience to the members, for material cannot be lost and is available at all times for ready reference.

A.S.M.E. Representatives on Washington Award Commission

AS RECENTLY announced the representatives of the A.S.M.E. on the Washington Award Commission are C. B. Nolte, president of the Crane Company, and Bernhard Schroeder, vice-president and chief engineer of Sargent & Lundy, Inc., both of Chicago.

Other organizations represented on the Commission are the Western Society of Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Institute of Electrical Engineers.

The award founded by John W. Alvord is administered by the Western Society of Engineers.

Riggs, Andrews, Benoit to Give Papers at Textile Meeting, Oct. 15

AS AN added attraction to the already interesting program planned for the one-day textile meeting in Boston, October 15, is the trip in the morning to the Hood Rubber Company at Watertown, Mass. Luncheon will be served at 12:30 in North Hall, Walker Memorial, at the Massachusetts Institute of Technology, and will be followed by the technical session.

The following papers will be presented at the session:

Recent Developments in Wet Finishing and Dyeing Machinery, by H. G. Riggs, Riggs & Lombard, Lowell, Mass.

Recent Developments in Textile Drying, by B. R. Andrews, Andrews & Goodrich, Inc., Boston, Mass.

Some Comments on the Growth of the Cotton Spindleage of This Country and Its Future, by A. W. Benoit, Charles T. Main, Inc., Boston, Mass.

The meeting is under the joint auspices of the Textile Division and the Boston Section of the A.S.M.E.

A.S.M.E. Peninsula Section to Be Host at Wood Industries Division Meeting, Grand Rapids, Mich., Oct. 8–9

THE PROGRAM is well advanced for the ninth national meeting of the A.S.M.E. Wood Industries Meeting at Grand Rapids, Mich., Oct. 8–9. Headquarters will be at the Pantlind Hotel.

Sessions are planned on gluing, sanding, machining operations, and costs at which papers and talks will be presented by many of the foremost leaders in the wood-industries field.

Members of the A.S.M.E. Peninsula Section are joining with members of the Wood Industries Division in planning excursion trips, luncheons, and entertainment features which do as much to make a meeting successful in one direction as the technical sessions do in another.

Friday's luncheon, which will be attended by members of the Grand Rapids Engineers' Club, will have as the speaker, F. E. Seidman, certified public accountant of Grand Rapids, who will talk on "The Economics of the Furniture Industry."

At the banquet on Friday evening to be held in the ballroom of the Hotel, the speaker will be A. P. Haake, managing director of the National Association of Furniture Manufacturers, who will take for his topic "Human Engineering."

On Saturday there will be a special luncheon of the officers of the Wood Industries Division and the Peninsula Section.

Inspection trips will round out the program with excursions to the plants of the American Seating Co., the Imperial Furniture Co., the Oliver Machinery Co., the Kindel Bed Co., as well as to the well-known Furniture Exposition.

The detailed program follows in the next column.

FRIDAY, OCTOBER 8

10:00 a.m. Gluing

Progress and Achievement of Hot-Press Plywood Bonding in Europe During the Last Ten Years, by L. M. C. Wegner, consulting engineer, Chicago

Recent Developments in Resinous Gluing, by E. H. Merritt, Merritt Engineering & Sales Company

A Study of Hot-Press Technique for Plywood, by Thomas D. Perry and Martin F. Bretl, Resinous Products and Chemical Company

12:30 p.m. Luncheon

Joint Luncheon with Grand Rapids Engineers Club

The Economics of the Furniture Industry, by F. E. Seidman, C.P.A., Grand Rapids

2:00 p.m.

Inspection trips to American Seating Co., Kindel Bed Co., Imperial Furniture Co., Oliver Machinery Co., G. R. Store Equipment Co.

6:00 p.m. Banquet

Human Engineering, by A. P. Haake, Managing Director of National Association of Furniture Manufacturers

8:00 p.m. Costs

Wastes in Lumber and Veneer Manufacture, by Martin Van Valkenburg, Grand Rapids

The Economical Application of Lumber Lifts, by Fred H. Meyer, Leitelt Manufacturing Co.

SATURDAY, OCTOBER 9

9:30 a.m. Sanding

An Investigation of Wood Sanding With Abrasive Belts, by A. M. Isaacson, Western Electric Company

The Effects of Speed and Pressure on the Cutting Rate of Coated Abrasive Products, by

Courtesy Grand Rapids Convention Bureau

PANTLIND HOTEL AT GRAND RAPIDS, HEADQUARTERS FOR THE A.S.M.E. WOOD INDUSTRIES MEETING

E. T. Hager, The Carborundum Company
Wood Industries Division and Peninsula Section Officers

10:30 p.m. Machining Operations

An Investigation in the Machining of Wood, by E. M. Davis, Forest Products Laboratories

A Method for Rating Comparative Machinability of Woods, by A. R. Tegge, Jr., American Box Board Company

12:30 p.m.

Luncheon—Wood Industries Division and Peninsula Section Officers

3:30 p.m.

Inspection trips to Furniture Exposition and points of interest

A cordial invitation is extended to all members to attend the meeting. A program and other information will be sent upon request to the A.S.M.E., 29 West 39th Street, New York, N. Y.

A.S.M.E.-A.I.E.E. Courses for Engineer License

AUTUMN educational courses are being given under the joint auspices of the Metropolitan Section of the A.S.M.E. and the Power Group of the New York Section of the A.I.E.E.

Joint review courses on structural planning and design and engineering economics and practice for professional-engineering-license applicants are starting immediately, as well as one course on mechanical engineering sponsored by the A.S.M.E. alone. There is also a class to start early in October on public speaking.

Detailed information regarding fees for the courses, hours, and room assignments may be secured directly from G. J. Nicastro, of the Combustion Engineering Co., 200 Madison Avenue, New York, N. Y., who is the representative of The American Society of Mechanical Engineers.

WILLIAM PENN HOTEL HEADQUARTERS FOR A.S.M.E.-A.I.M.E. MEETING

A.S.M.E. and A.I.M.E. to Meet at Pittsburgh, Pa., Oct. 27–29

Fuels and Coal Divisions Unite to Present Group of Excellent Papers

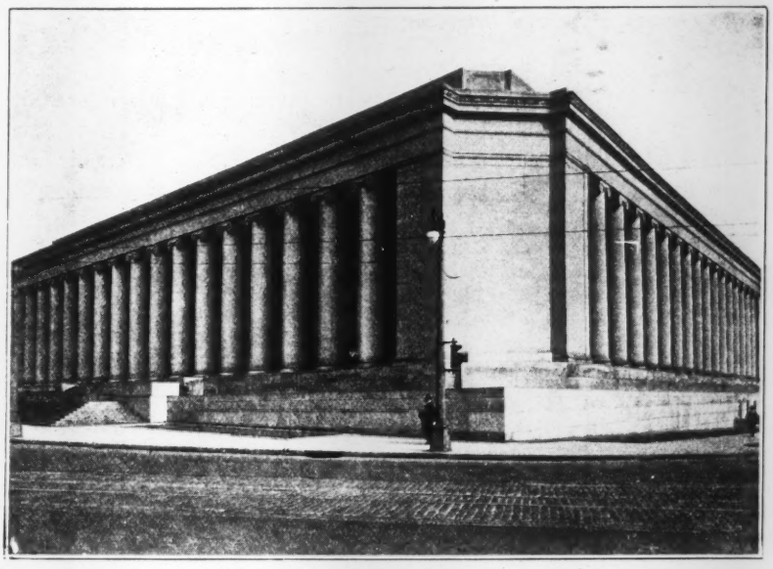
THE PROGRAM of papers and events for the joint meeting of the Fuels Division of the A.S.M.E. and the Coal Division of the A.I.M.E. to be held at Pittsburgh, Pa., October 27 to 29, gives every promise of interesting as well as valuable coal sessions. Headquarters for all sessions will be at the William Penn Hotel.

Inspection trips are planned to the Champion coal-cleaning plant of the Pittsburgh Coal Company and the Colfax Station of the Duquesne Light Company. Other trips may be arranged as desired to Mellon Institute, Carnegie Institute of Technology, and the U. S. Bureau of Mines laboratories.

The program is as follows:

WEDNESDAY, OCTOBER 27

9:00 a.m. Registration, William Penn Hotel



Courtesy Pittsburgh Chamber of Commerce

THE NEW MELLON INSTITUTE BUILDING IN PITTSBURGH

10:00 a.m.

Technical Session

Chairman: William G. Christy
Vice-Chairman: G. B. Gould
Introductory remarks, Howard N. Eavenson
Chain- or Traveling-Grate Stokers, by G. A. Anbro, power engineer, Colgate-Palm Olive-Peet Co., Jersey City, N. J.
Underfeed Stokers From the Standpoint of Coal Selection, by J. E. Tobey, manager, fuel-engineering department, Appalachian Coals, Inc., Cincinnati, Ohio.

2:00 p.m.

Technical Session

Chairman: J. E. Tobey
Vice-Chairman: A. R. Mumford
Economics of Preparing Coal for Steam Generation, by H. F. Hebley, advisory engineer, Commercial Testing and Engineering Co., Chicago, Ill.
The Chemical Treatment of Coal and Coke, by P. Nicholls, U. S. Bureau of Mines.
Fundamental Factors Involved in the Dust-proofing of Coal, by M. F. Fife, Mellon Institute, Pittsburgh, Pa.

THURSDAY, OCTOBER 28

9:30 a.m.

Technical Session

Chairman: J. B. Morrow
Vice-Chairman: S. B. Ely
Theoretical and Practical Aspects of Segregation in the Handling of Coal, by D. R. Mitchell, assistant professor of mining engineering, University of Illinois, Urbana, Ill.
Statistical Interpretation of Laboratory Coal Tests and Sampling Methods, by G. B. Gould, president, Fuel Engineering Co., of New York, New York, N. Y.

2:00 p.m.

Technical Session

Chairman: T. A. Marsh
Vice-Chairman: H. F. Hebley
Selection of Coal for Pulverized Firing, by

B. E. Tate, chief engineer, power plant, National Cash Register Co., Dayton, Ohio.

Small Underfeed Stokers, by Engineering Committee of Stoker Manufacturers Association; G. M. Guthrie, *Chairman*

The Status of Our Knowledge of Coal Selection for Steam-Generating Equipment, by Ralph E. Sherman, Fuel Engineer, Battelle Memorial Institute, Columbus, Ohio.

2:00 p.m.

Safety Session

Chairman: J. T. Ryan

Vice-Chairman: J. J. Rutledge

Inspection and Safety of the Island Creek Properties, by A. J. Bartlett, chief mine inspector, Island Creek Co., Holden, W. Va.

Effective Methods of Eliminating Gas Ignition in Coal Mines, by W. B. Hillhouse, chief, Department of Mines, Birmingham, Ala.

Observations on Nova Scotia Mining Practice, by T. L. McCall, Dominion Steel and Coal Corporation, Sydney, Nova Scotia.

6:30 p.m.

Banquet

To be held at William Penn Hotel.

Toastmaster: Alex D. Bailey, Vice-President, A.S.M.E.

Speaker: Charles Hosford, chairman, National Bituminous Coal Commission.

FRIDAY, OCTOBER 29

9:00 a.m.

Inspection Trips to Champion No. 1 Cleaning Plant of Pittsburgh Coal Co. and Colfax Station of Duquesne Light Co. Other trips to Mellon Institute, Carnegie Institute of Technology and U. S. Bureau of Mines Laboratories will be arranged for those who desire to visit these institutions.

A.S.M.E. Oil-Gas Power Meeting at State College, Pa., Has Record Attendance

Meeting Attracts Operators, Research Workers, and Builders

IN COOPERATION with the School of Engineering of the Pennsylvania State College and Central Pennsylvania Section of The American Society of Mechanical Engineers, the Oil and Gas Power Division held its tenth national meeting at the Nittany Lion Inn, State College, Pa., August 18 to 21, 1937. The registration, including guests, was approximately 300, or nearly ten times that of the first national meeting held at State College in 1928. More than a dozen manufacturers of Diesel engines, parts, and equipment participated in an exhibit held at the Inn.

Dean Sackett Welcomes Guests to State College

The first technical session was held on Wednesday afternoon with Ernest Nibbs, chairman of the Oil and Gas Power Division, presiding. A reel of film showing the manufacture of the Fairbanks-Morse Diesel-injection system was shown following an address of welcome by Dean R. L. Sackett, of the School of Engineering, who also read a letter from Dean-Elect H. P. Hammond. Progress reports by manufacturers and operators, a feature introduced into the program for the first time this year, were then presented. The officers of the division had thoughtfully provided copies of these progress reports, as well as copies of all papers, available in advance, to be presented at the sessions, and a complete set of these was offered on payment of the registration fee of one dollar. The progress reports were assembled from statements prepared by the manufacturers and operators. Representatives of the various companies were restricted to three and one-half minutes each in presenting their reports.

Following these reports was a paper on "U. S. Navy Participation in Diesel-Engine Development," by E. C. Magdeburger, Bureau of Engineering, U. S. Navy Department, which was published in the September issue of MECHANICAL ENGINEERING.

Fuels and Lubrication Discussed

Carl Behn, of the Otto Engine Division, National Supply Company of Delaware, presided at Thursday morning's session devoted to fuels and lubrication. At this session A. T. McDonald read a paper by C. G. A. Rosen, of the Caterpillar Tractor Company, entitled "Lubricating Problems in Connection With High-Speed Diesel Engines," in which he illustrated the importance of cooperative research of engine manufacturers with the petroleum industry. This was followed by a brief review of some of the work done at the U. S. Naval Engineering Experiment Station in correlating the results of the physical-chemical and C.F.R. engine ignition-quality tests with fuel performance in service engines, entitled "Correlation of Laboratory Tests on Diesel Fuels With Service Engine Operation."

Presiding over the Thursday afternoon session on transportation was Harte Cooke, of the American Locomotive Company. Martin Schreiber, Public Service Coordinated Transport Company, spoke extemporaneously on "Diesel-Electric Bus Operation."

Operating Session Develops Discussion

At the operating session on Friday morning, with L. M. Goldsmith, Atlantic Refining Company, presiding, an N.A.C.A. film showing slow-motion pictures of combustion conditions with several arrangements and types of spray nozzles was shown. H. C. Major, chairman, Oil-Engine Power Cost subcommittee, presented the 1936 Report on Oil-Engine Power Cost, an activity of the division that is attracting considerable favorable comment. This year's report includes information from 166 oil-engine generating plants, containing 458 engines, totaling 246,665.5 rated bhp, with a total net output of 357,409,184 kwhr. Items covered in the report are fuel cost, lubrication cost, cost of attendance and superintendance, cost of supplies and miscellaneous, and cost of engine and plant repairs. The first report, 1929, listed 36 plants, the number included in each successive report having grown as the value of the report became evident to all persons interested in Diesel engines. The report, a 36-page pamphlet, is available for purchase at $1 per copy.

Much interest centered around a paper on "Sewerage Gas Engines," by W. B. Walraven, of the Springfield, Ill., Sanitary District, which raised many points for discussion. This was followed by a paper on "Waste Heat Recovery From Diesel Engines," by Glenn C. Boyer, Burns and McDonnell Engineering Company, Kansas City, Mo. By vote of those present, discussion was continued during the afternoon, when another paper, "Penn State Method of Diesel-Fuel Testing," was presented by J. S. Chandler, research assistant, Engineering-Experiment Station, The Pennsylvania State College.

Saturday's session was under the chairmanship of P. H. Sweitzer, of Penn State. K. J. DeJuhasz, also of Penn State, read a paper entitled "Oil Flow Through Fuel Nozzles," and a paper by William H. Hubner and Gustav Egloff, Universal Oil Products Company, Chicago, Ill., entitled "A Study of Diesel Fuels," was also presented.

Papers to Be Published

Papers presented at these sessions will be reviewed by the officers of the division who will make recommendations regarding future publication in the Society's Transactions.

In spite of the excessively warm and humid weather, discussion at all technical sessions was active and protracted. The division's meetings attract operators as well as research workers in Diesel engines, and many builders of engine and accessory equipment and representatives of the petroleum industry. Discussion is frank and all sides of many subjects are threshed out to the benefit of every one present. For sustained interest in a subject with many important angles, meetings of the division are unusually profitable.

Dinner Tops Social Events

While the heat interfered with some of the social events scheduled, it did not prevent a golf match on Friday afternoon, for which the Committee on Entertainment and Sports provided prizes. Winners were announced at the dinner on Friday night which filled the dining room of the Inn. Ernest Nibbs acted as toastmaster and Dean Sackett and James H. Herron, president of the Society, spoke.

Dean Sackett, who retires from his duties at State College this year, recalled the growth of the division and the increasing attendance at its meetings, and was accorded an enthusiastic ovation in recognition of his services not only to the division but also to engineering education.

President Herron reviewed the history of the division which started early in the century as the Gas Power Division under the guidance of

Prof. Charles E. Lucke and Geo. A. Orrok. He reminded his audience that the division's interests would be well-served by Harte Cooke, nominee for vice-president of the Society. He spoke also of the improved financial condition of the Society and paid tribute to Col. Paul Doty's administration during the depression. He concluded his brief remarks by praising the quality of the papers presented at the tenth national meeting of the division and by thanking the authors and the members of the division and its various committees for their services. The Oil-Engine Power Cost Report, he said, warranted the widest publicity.

Following the dinner a film was shown by the Socony-Vacuum Oil Company.

Many Helped in Program

The committee on arrangements for the meeting was under the chairmanship of F. G. Hechler, of State College. In charge of registration was E. R. Queer. P. H. Schweitzer was in charge of technical sessions. The members of the committee were Oliver F. Allen, L. T. Brown, J. S. Chandler, J. S. Doolittle, G. W. Good, Raymond Haskell, L. H. Morrison, Paul Newman, P. J. Reber, and F. M. Torrance. The Technical Program Committee consisted of L. H. Morrison, chairman, Harte Cook and Lee Schneitter. K. J. DeJuhasz was in charge of the Exhibits Committee, with Carl Behn, Ralph Miller, R. Y. Sigworth, and F. C. Stewart assisting. Presiding over sports and entertainment was a committee of which E. L. Keller was chairman consisting of H. A. Everett, W. K. Gregory, N. R. Sparks, and R. W. Wadman. A "Daily Bulletin" was issued under the guidance of Prof. C. L. Allen, and a committee consisting of Ernest Hartford, W. G. C. Thompson, and A. H. Zerban.

Provision for the large number of women attracted to State College by its beautiful location and memories of previous meetings was made by a committee of which Mrs. F. G. Hechler was the gracious and hospitable chairman. Assisting her were Mrs. K. J. DeJuhasz, Mrs. H. A. Everett, Mrs. L. H. Morrison, Mrs. Ernest Nibbs, Mrs. E. R. Queer, Mrs. M. J. Reed, Mrs. Lee Schneitter, and Mrs. P. H. Schweitzer.

While appropriate credit must be given to the various special committees responsible for the 1937 meeting, the executive committee of the division bears the responsibility of plans and policies, and too much credit cannot be given its chairman Ernest Nibbs and its secretary, M. J. Reed. Other members of the committee are F. G. Hechler, Edgar J. Kates, L. H. Morrison, and Lee Schneitter. Associates are Carl Behn, Harte Cooke, L. R. Ford, L. M. Goldsmith, H. C. Major, and Ralph Miller.

A.S.M.E. Calendar

of Coming Meetings

October 4–6, 1937
National Fall Meeting
Erie, Pa.

October 8–9, 1937
Wood Industries Meeting
Grand Rapids, Mich.

October 15, 1937
Textile Meeting
Boston, Mass.

October 27–28, 1937
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Pittsburgh, Pa.

December 6–10, 1937
Annual Meeting
New York, N. Y.

March 23–25, 1938
National Spring Meeting
Los Angeles, Calif.

June 20–24, 1938
Semi-Annual Meeting
St. Louis, Mo.

Exhibit of Photography for Engineers at 1937 A.S.M.E. Annual Meeting

Prints Should Be Received Between November 1 and 20

AS NOTED in the September issue of MECHANICAL ENGINEERING, page 713, members throughout the country are invited to submit pictorial or technical prints for the forthcoming exhibition. Prints should be about 8 × 10 in. and simply mounted on plain, light-colored cards about 15 or 16 by 20 inches. Prints should be received between Nov. 1 and Nov. 20, by Mr. John F. Guinan, Annual Photographic Exhibit, A.S.M.E., 29 West 39th Street, New York, N. Y.

Prospective exhibitors in and near New York are invited to attend the Metropolitan Section, Photographic Group meeting on October 20, at 7 p.m. in Room 1101, 29 West 39th Street, when J. G. Lootens, Carl Zeiss, Inc., will discuss "The Making of Exhibition Prints."

Junior Group Activities

Los Angeles Junior Section Grows

IN THE midsummer news bulletin of the Los Angeles Section, The American Society of Mechanical Engineers, Wm. Howard Clapp, chairman, issues an invitation to the junior members of that section to present papers with prepared discussions by members of senior and junior groups. Complimenting the juniors for the high quality of many papers presented by them in the past, Mr. Clapp calls attention to the fact that the junior membership of the section is rapidly approaching one half of the total membership. Chairman of the Junior Section is E. Kent Springer.

Metro Juniors Open With Talk by R. M. Gates

R. M. GATES, vice-president, Superheater Company and the Combustion Engineering Company, Inc., will address the first meeting of the current program of the Metropolitan Junior Group, The American Society of Mechanical Engineers, on the subject, "What is Your Objective?" The meeting will be held on Oct. 5, at 7:30 p.m. in Room 1101 of the Engineering Societies Building, 29 West 39th Street, New York, N. Y.

Mr. Gates will deal with the problems facing the young engineer—a subject which has held his interest for many years. His talk will include deductions made from his observations and his contacts with many people in all walks of life, and will be of informal nature. A general discussion and question period will follow, and sociability and congeniality will be stressed throughout the meeting.

A similar talk, "Advice to Young Engineers," was presented by Mr. Gates at a Student Conference at Chattanooga on April 19, 1937. The student branches taking part in the conference were enthusiastic in their response, and the suggestion was advanced that the talk be printed in pamphlet form for distribution to student members in other parts of the country.

Mr. Gates, who is a fellow and former manager and vice-president of the A.S.M.E., was born in Iowa, raised in the Dakotas, Kansas, Missouri, and Illinois, and was graduated from Purdue University. He describes his industrial experience: "I have worked at many occupations from a tomato-canning factory and a handle factory where all I did was to push holes in a shovel handle, to scraping grease off a locomotive in a roundhouse, being a machinist, and a professional engineer, according to my New York State license."

Arrangements for the meeting of October 5 have been made by the Metropolitan Junior Group's Program Committee, headed by Robert M. Baker. H. H. Edwards of the Porete Manufacturing Company, will preside.

Junior Group Organization

SENIOR and Junior Members of the Society do not generally realize that Junior Groups of The American Society of Mechanical Engineers are more than loosely thrown to-

gether groups, and that considerable organization work is necessary before a smoothly working unit is obtained. The following is a résumé of the set-up provided by the by-laws of a representative Junior Group.

Officers include a chairman, vice-chairman, and secretary. These men, together with others elected from the membership by sealed letter ballot, comprise the Executive Committee which supervises the affairs of the Group and its standing and special committees. The heads of these committees join with the Executive Committee to form an administrative unit which coordinates the efforts of each unit toward the accomplishment of the aims of the Group. An annual report is submitted, copies of which are usually sent to the local Section and to A.S.M.E. Headquarters in New York.

Representative committees are those charged with duties allied with problems of program, membership, publicity, nominations, seminars, employment advice, and social affairs.

Committees Study Junior-Group Survey Results

FORTY per cent of the Juniors who responded to the annual Survey Form and questionnaire of the Metropolitan Junior Group have indicated a desire to take part in the work of the various committees of the group. This does not include those members already serving in this capacity.

Another result of the questionnaire was the indication of mounting interest in labor problems and unionism among the ranks of young engineers, reflecting the effect of recent agitation. Of 71 subjects offered for use as topics for general meetings of the Metropolitan Group, none was more frequent than "Labor Problems," "Labor Relations," and "Unionism." Of 46 topics suggested for other meetings, the most mentioned was the junior engineer and the business and social problems confronting him.

The Survey Form has already drawn over twice as many replies as were received last year, despite the fact that fewer forms had been distributed at press deadline for this issue of MECHANICAL ENGINEERING. The new and easy-to-fill-in questionnaire developed by the Survey Form Committee has brought considerable favorable comment upon the work of S. Davidson, chairman, and G. L. Lingner. Its aim was to point out to Juniors the advantages and privileges of their membership, review last year's program of the Metropolitan Group as well as plans for the future, and to give each Junior a chance to suggest his own program topics.

Eighty-two per cent indicated that they had been student members, and 74 per cent that they had transferred directly from student to Junior membership. Replies were largely from Juniors who were graduated from colleges of the Metropolitan area since 1930. Thirty-five per cent indicated that they would like to obtain the counsel of the Metropolitan Junior Group Employment Advisory Service in the near future, indicating the unsettling influence of the recent period of depression.

With the Student Branches

Officers for the Fall Semester

GREAT doings are in store for the Student Branches this coming fall under the able guidance of the following officers: WORCESTER, Gleason W. Jewett, Oscar A. Fick, Byron H. Wilson, and Robert Karakoosh . . . . . WISCONSIN, William Mitchell, Roger Stanley, J. Dobrogowski, and Arthur Thom . . . . . WASHINGTON UNIVERSITY, John Toedtman, Robert Seifert, David Hassemer, and Thomas O'Neill . . . . . VANDERBILT, Graham Finley, Edward Poste, Fred Woods, and Ned Wallace . . . . . UNIVERSITY OF TEXAS, J. C. Hight, E. J. Wacker, R. T. Lee, and R. E. Powers . . . . . UNIVERSITY OF SOUTHERN CALIFORNIA, Elmer Salomonson, Frank White, and Charles Walker . . . . . RHODE ISLAND STATE COLLEGE, Richard Henry, Chace Sherman, Robert Hull, Albert Marshal, Henry Barker, and Frank DeLuca . . . . . RICE INSTITUTE, John Wissenger and L. F. Wolfram . . . . . PRATT INSTITUTE, C. J. Roddy, W. M. Morsell, and F. W. Fiala . . . . . PITTSBURGH, G. E. Horvath, J. C. Tredennick, R. L. Freeburg, and T. Garrahan . . . . . OREGON STATE, Stanley R. Kelley, Geo. M. Cunningham, Clyde R. Dean, Edward Moore, and Donald Wimberly as Sgt.-at-arms . . . . . OHIO STATE UNIVERSITY, E. M. Smith, W. H. Kuntz, H. A. Fox, and H. R. Kroeger . . . . . NEW YORK UNIVERSITY (evening), Milton J. Berg, Claude Petruzzi, Maurice Steinfeld, William Resnikoff, and Paul Faber . . . . . NEBRASKA, Harold Brown, Harry Brown, Edmund Carlson, and Don Payne . . . . . UNIVERSITY OF MISSOURI, Earl Fallin, Herbert Baugh, and Melvin Yedlin . . . . . LOUISIANA STATE UNIVERSITY, L. T. Weathers, Samuel Lawrence, Paul Sindo, and Anon Day . . . . . KANSAS UNIVERSITY, George Russel, George Cobb, Frederick Thudium, and Don Barnett . . . . . IOWA STATE COLLEGE, Floyd Selim, Horace Boyd, Hubert Bierman, and Kreigh Carney . . . . . GEORGE WASHINGTON UNIVERSITY, L. W. Froyd, R. Spellman, R. D. Pfahler, and C. F. Gareau . . . . . DETROIT, Edward Connolly, William K. Wittig, John Zynda, and Arthur Kemsley . . . . . CLEMSON, W. J. DeWitt, B. S. Jordan, and E. J. Galvanek . . . . . CALIFORNIA INSTITUTE OF TECHNOLOGY, Charles Clarke, Ralph Jones, Stanley Voorhees, and Herbert Ellis.

Making Meetings More Interesting

RHODE ISLAND STATE COLLEGE BRANCH intends to hold joint meetings with the other engineering societies' student branches. Papers are to be presented exclusively by the student members . . . . . Last semester, many student members presented papers based on articles appearing in MECHANICAL ENGINEERING. W. D. Wuest of the UNIVERSITY OF LOUISVILLE BRANCH used an article from the April, 1937, issue on a 270-ton double-trolley gantry crane at Wheeler Dam . . . . . At GEORGE WASHINGTON UNIVERSITY BRANCH, the outstanding senior according to his fellow members is presented at the end of the year with one year's dues as a Junior Member of the Society . . . . . Many student branches hold joint meetings with branches from other schools. Some of those who have done so in the past were M.I.T., TUFTS and NORTHEASTERN in New England and NORTH CAROLINA, NORTH CAROLINA STATE, and DUKE in the South . . . . . NOTRE DAME BRANCH last spring experimented by having the junior student members plan and conduct the branch meetings . . . . . And then there are prominent engineers who consider it an honor to talk to the members of a student branch . . . . . Every time a student branch has a meeting or an inspection trip, the corresponding secretary should write a brief but complete report about the affair and send it in to Headquarters immediately. Names of student members who had anything to do with the meeting

A.S.M.E. STUDENT BRANCH MEMBERS AT PRATT INSTITUTE

(Seated, from left to right: John B. Thomson, William A. Freer, chairman, Francis W. Fiala, secretary-treasurer. Standing, from left to right: Richard C. Knowles, R. Burdette Dale, honorary chairman, Hugh S. Cameron, Van Cleve Shelley, Clarence J. Boddy, vice-chairman.)

or trip should be mentioned so that we can give them full credit in this column. Other branches are interested in what your branch is doing as long as it is educational or interesting.

This and That

Out at Iowa State College, the Student Branch erected a float last spring for the annual Veishea Parade which showed the progress of heating and ventilating engineering . . . . . Pratt Institute Branch held a spelling bee between the seniors and juniors based on technical words taken from the last few issues of Mechanical Engineering. A. P. Henry won the contest and was awarded a Kent's Mechanical Engineering Handbook . . . . . Minnesota Branch not only has some fine technical meetings but they also have some interesting trips and parties. A trip was taken to the operating room of the University Hospital where actual operations were viewed by the members. At a social gathering sponsored by the branch, a German band furnished music and the branch's mascot, a fox terrior, did tricks "until his tongue was dragging" . . . . . Kenneth G. Hess student chairman of the Louisville Branch presented a paper on automobiles over radio station WHAS last Spring . . . . . Iowa State College Branch ran a picnic as the climax to a big membership drive initiated by the officers . . . . . Down in the sunny South, Louisiana State Branch selected a Queen to represent it at the annual Engineers' Ball . . . . . Up in New York, Brooklyn Polytechnic Branch organized a bowling team which scored a victory over a faculty team . . . . . What's happening at your Student Branch? Get your corresponding secretary, news editor, or anyone interested in writing to make up a report and send it in right away. We'll print it if it's interesting.

More Than 1500 in Attendance at Student Meetings Held in Spring

Nine Hundred Dollars in Cash Prizes Awarded; 123 Papers in Competition

SINCE this is the first issue of Mechanical Engineering to be made available to A.S.M.E. Student Members for the 1937–1938 school year, a brief résumé of last spring's student meetings attended by more than 1500, may not be amiss.

Travel Long Distance to Attend

An interesting point about these meetings is the distance that many of the students are willing to travel for the privilege of attendance. To cover the necessary traveling expenses ten cents a mile one way is allowed to the official contestants and the honorary chairmen of the branches and this is usually spent to defray the cost of operating two or more automobiles to permit of taking a number. As many as 22 students traveled 800 miles each way to attend the group meetings.

There were 123 papers in all delivered at the ten meetings by students in competition and the tabulated list of those winning prizes accompanies this article. (See page 794.) Nearly $900 in prizes was presented in addition to many smaller awards, among the most popular being the slide rules donated by the SKF Company. At each meeting there were three official awards of $50, $25, and $10. However, in several instances additional prizes of $5 were made available through the generosity of members of the Local Sections.

Group I Tries New Method of Judging

A new method of judging the papers was tried this year by Group I and in many respects worked more favorably than the former way. From each of the fourteen colleges taking part in the meeting a professor and student were chosen to act as judges, instead of a group of engineers from industry. The plan is to be repeated this coming spring with slight modifications.

A feature of all the meetings was the opportunity given to the students to visit industrial plants where work was proceeding in full blast and they could actually see theories put into practice.

Dr. Durand's Talk of Particular Interest

At each of the meetings also there was a special luncheon for the students attended by members of the local engineering societies as well as A.S.M.E. Local Section members and a banquet addressed by engineers of prominence in the community. Of particular interest was the talk given by Dr. William F. Durand, past-president of the A.S.M.E., at the banquet held at the San Francisco Engineers' Club. Dr. Durand analyzed the position both of the engineer and of the scientist in our social structure and discussed his assumed and obligatory responsibilities as a technician and as a citizen with special qualifications. In particular, he dwelt upon the problem of conserving our resources of material and energy and upon the grave social problems facing the citizen today due in large measure to the work of engineers in the last two centuries. A balance must be reached, he said, between our nervous control and the demands made upon it, and between the material content of our civilization and the uses we are making of it.

At all of the meetings senior councilors of the Society and other officers and members of the Committee on Relations With Colleges were in attendance and their reports of the meetings are uniformly enthusiastic, in particular stressing the fact that they give an opportunity for the students to become familiar with the work of the A.S.M.E.

Building at Stevens Institute Named in Honor of Dr. D. S. Jacobus

A NEW dormitory, Jacobus Hall, opening this fall at Stevens Institute of Technology, has been named at the request of its donor William S. Barstow, in honor of David S. Jacobus, Stevens, 1884, past-president and honorary member of the A.S.M.E. Dr. Jacobus was for 22 years a member of the faculty at Stevens and since has been engineer in charge of research at the Babcock & Wilcox Company. He has also been a trustee of the Institute since 1909.

Jacobus Hall will house 21 men. It is also designed to serve as a social center for the whole college. On the first floor will be a large lounge flanked by an open-air terrace commanding a fine view of the Hudson River and of Manhattan. Adjacent to the lounge at one end is the music center of the College. At the other end is a game room, a reading and study room, and a reception hall.

The accompanying illustration is from the architect's wash drawing.

A.S.M.E. Student Group Meetings, 1937

GROUP I—NEW ENGLAND STUDENT MEETING, PROVIDENCE, R. I.

Attendance: 137 Papers presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	Raymond Warren	Determination of Automobile Resistance From Road Tests	Rhode Island State College
Second	John Wilson	The Winkler Rotary Engine	Northeastern Univ.
Third	Walter Holt	Possibilities in the Development of Boron Carbide as a Metallurgical Compound	Worcester Poly. Institute
Fourth	E. C. Peterson	The Development of Rod Mills	Mass. Inst. of Tech.

GROUP II—EASTERN STUDENT MEETING, NEW BRUNSWICK, N. J.

Attendance: 206 Papers presented: 13

Prize	*Recipient*	*Title of Paper*	*College*
First	Marshall C. Long	The Directional Blade Propeller	Princeton Univ.
Second	Willard Gardner	A Wind-Tunnel Comparison of Marconi and Gaff-Rigged Sails for Boats	Rutgers Univ.
Third	Arnold B. Arons	Factors Affecting Nitric-Oxide Formation in Internal-Combustion Engines	Stevens Inst. of Tech.
Fourth	G. L. McFarland	Tensile-Impact Tests on Welds at Low Temperatures	Poly. Institute of Brooklyn

GROUP III—ALLEGHENIES STUDENT MEETING, COLUMBUS, OHIO

Attendance: 194 Papers presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	D. H. Cornell	Principles of Wire Drawing	Univ. of Akron
Second	W. B. Seaver	Wing De-icers for Air Transports	Case School of Applied Science
Third	Arthur Kiess	A Method of Testing Small Pop Safety Valves	Ohio State Univ.
Fourth	Ian M. Hamer	Aeroplane Skiis	Univ. of Toronto

GROUP IV—SOUTHERN STUDENT MEETING, CHATTANOOGA, TENN.

Attendance: 202 Papers presented: 15

Prize	*Recipient*	*Title of Paper*	*College*
First	N. I. Gebhart	Telescopes	Univ. of Kentucky
Second	H. S. Evans	Some Mechanical-Engineering Features of a Modern Plant	Duke University
Third	B. D. Henderson	The Economic Feasibility of the Heat Pump	Vanderbilt University
Fourth	Irving Lipton	The Effect of Combustion-Chamber Design on Engine Performance	Georgia School of Tech.

GROUP V—MID-WEST STUDENT MEETING, CHICAGO, ILL.

Attendance: 275 Papers presented: 17

Prize	*Recipient*	*Title of Paper*	*College*
First	H. R. Sennstrom	Railway Transportation Power Requirements	Purdue University
Second	C. E. Tarpley	An Investigation of Properties of Wood	Univ. of Illinois
Third	S. M. Miner	The Domestic Underfeed Stoker	Armour Institute
Fourth	E. W. Connolly	Sit-Down Strikes and the Engineer	Univ. of Detroit

GROUP VI—NORTHERN UNIT STUDENT MEETING, KANSAS CITY, MO.

Attendance: 85 Papers presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	Clarence Nielsen	Portland Cement and Rubber Cement Used as Binders for Foundry Cores	Kansas State College
Second	T. O. Thompson	Real and Imaginary Gases	Univ. of Missouri
Third	R. J. Bentson	Detonation in Automobile Engines	South Dakota State College
Fourth	B. N. Bailey	Automatic Transmissions	Univ. of Kansas

GROUP VI—SOUTHERN UNIT STUDENT MEETING, STILLWATER, OKLA.

Attendance: 153 Papers presented: 18

Prize	*Recipient*	*Title of Paper*	*College*
First	I. W. Lovelady	Velocity-Meter Coefficients	University of Oklahoma
Second	Henry Meredith	The Design of a Gas Burner for an Internally Fired Boiler	Texas Technological College
Third	C. M. Howell	The Conversion of a Medium-Size Oil-Burning Diesel Engine to a Gas Engine	Texas Technological College
Fourth	James A. King	Failure of Machine Parts by Progressive Fracture	Oklahoma A. & M. College

GROUP VII—NORTHWEST UNIT STUDENT MEETING, MOSCOW, IDAHO, AND PULLMAN, WASH.

Attendance: 100 Papers presented: 10

Prize	*Recipient*	*Title of Paper*	*College*
First	Don Avery	The Integrating Velocitometer	Univ. of Washington
Second	Walfred Carlson	The Electric-Drive Locomotive	Univ. of Idaho
Third	Henry Baila	Burning Washington Coal in Domestic Stokers	State College of Washington
Fourth	S. D. Hage	Supercharging the Passenger-Automobile Motor	University of Washington

GROUP VII—CENTRAL UNIT STUDENT MEETING, LARAMIE, WYOMING

Attendance: 53 Papers presented: 8

Prize	*Recipient*	*Title of Paper*	*College*
First	Charles Newcomb	Modern Home Insulation	Univ. of Wyoming
Second	B. E. Baily	Inspection of Refinery Equipment	Colorado School of Mines
Third	E. V. Garnett	A Dual Front Wheel Mounting for Busses, Trucks, and Other Heavy Vehicles	University of Colorado
Fourth	D. H. Jarvis	The Development of a Self-Regulating Fan for Use in Domestic Stoker Operation	University of Utah

GROUP VII—SOUTHWEST UNIT STUDENT MEETING, STANFORD UNIVERSITY, CALIF.

Attendance: 89 Papers presented: 12

Prize	*Recipient*	*Title of Paper*	*College*
First	R. W. Jones	A New Method of Measuring Open-Channel Flow	Calif. Inst. of Tech.
Second	J. E. Lindberg, Jr.	The Slotted Propeller	Univ. of California
Third	W. J. Adams, Jr.	Ionization in Air Conditioning	Univ. of Santa Clara
Fourth	E. C. Rollins	What About the Future Automobile?	Univ. of Nevada

The Members' Page

A Forum for Frank Discussion by A.S.M.E. Members

The Engineer and His Societies

THE MEMBERS' PAGE:

The engineering profession is one of the youngest although the practice of engineering is probably the oldest of all. The medical and legal professions are no doubt the best organized and most exclusive in existence today. On the other hand, engineering is the most unorganized profession of all.

Mainly, the engineering societies are divided into two groups of national societies, namely, technical and professional. At least one hundred different technical societies in the United States serve various divisions of engineering, but only one professional society is concerned with all the branches of engineering.

Each technical society is concerned with its own specialized branch of engineering. In its particular field, each technical society is an important unit and performs useful work. Its activities are restricted, as much as possible, to its own division of engineering. Obviously, it will be only a matter of time before this type of organization will yield to the demand for broader engineering interests.

In this connection, it is interesting to note the trend of our leading engineering schools. Many of them have realized the disadvantage of offering specialized courses leading to degrees in one particular field of engineering. This type of course no longer has the appeal it used to have. Conditions today demand that an engineer have a broad educational background.

Engineers should be leaders in industry and, as leaders, should possess broad engineering viewpoints. The chief engineer today is not a specialist. His problems are mechanical, electrical, chemical, etc. To keep informed on the latest developments, he would have to participate in the activities of all of the various societies. Very often, these activities are held at the same time, so that it is impossible to participate and, quite often, they overlap and even duplicate those of other societies, so that the engineer soon becomes disinterested. Therefore, it is difficult for him to become associated with several technical societies to derive the benefit he desires from each.

Since the engineer coordinates all branches of science in his work, so he would like to see one integral technical engineering society. This should be composed of all the present technical societies. Each component part of the society should carry on the work of its particular division in specialized fields of engineering.

Thus, the engineer would be associated with one single society which would be able to serve him more readily and more efficiently. His technical interests would be centralized and at the same time, he would have the advantages of specialization in all branches of engineering.

In addition to the difficulty the engineer has with his technical associations, he quite often has to compete with untrained and unqualified men. This condition is undesirable and is perhaps the direct result of poor organization in the engineering profession. However, it may be overcome by proper legislation and strict enforcement of the license laws.

The public must be protected and should have qualified engineers do engineering work. The professional society is concerned with the practice of engineering only by those who are trained and qualified and have met certain minimum requirements which apply to every engineer. The professional society devotes itself to the economic and welfare problems of the profession in its relations to the public and to the individual engineer.

Interests of all engineers are on a common basis in this society. It is the largest organization of engineers united for advancing the interests of the profession as a whole. Every qualified engineer has invested much time and money in the training for and the practice of his professional career. The professional society is organized to protect and increase the value of this investment.

At present, it might be well to point out that the engineering profession should not be allowed to become associated with unions. These bodies, whether vertical or horizontal, endeavor to ameliorate working conditions for their members. The purpose of the professions, whether engineering or otherwise, is the safeguarding of all human beings and the improvement of living conditions. Therefore, it would be unwise for the professional men to take sides as their professional judgment demands impartial exercise of their training and experience.

Eventually the day will come when the engineer will demand one professional association similar to the American Medical Association and the American Bar Association. Perhaps it will be the "American Engineering Association." This association should be composed of all the present technical and professional societies. All of the engineer's fraternal interests would be centralized with this arrangement. He would be served more efficiently and would perform his duties with greater general ability.

It has been said that the greatest difficulty with mankind is the incapacity of the mind to view matters from all angles. Perhaps this is another reason for poor organization in the engineering profession. Until recently, the engineer has interested himself only in the technical side of his profession. However, he has come to realize that for him to serve the public more fully, he should also interest himself in the social side of his profession. Thereby, he is developing himself into a real leader by viewing his profession from all angles.

Advantages of consolidation may be illustrated by the Engineering Societies' Library which is composed of the libraries of several technical societies. While each technical society lost its individual library, the combined library gained in size, importance, and ability to serve and became the finest engineering library in the United States, if not in the world. Use of thi library is now of great value to members of the individual societies.

Engineering societies might also be compared with the various departments of present-day corporations. Each department is a small corporation in itself and doing its own particular work. However, unless the work of each department is coordinated to form a part of the work of the corporation, the business will not be carried on efficiently. Each department, like the societies, should work together for the mutual benefit of all. As an example, a corporation had a vice-president in charge of each of its major departments, who differed in length and quality of service. Soon the time came when a new president had to be appointed from these vice-presidents. The man chosen did not have the longest service nor was he in charge of what was considered the most important department. He was a man who had the capacity of viewing the operations of each department from all angles. He had to be a man with an appreciation of the work of each department and yet have the greatest ability to guide their efforts toward a unified goal.

A unified engineering profession should be the goal of every engineer. Through his various societies every engineer can do much to obtain this result. No doubt the process will be slow and many discussions will take place and much time will be spent in arriving at a suitable basis for unification. However, it is hoped that in the not too distant future engineering will succeed as a unified and organized profession.

GEORGE J. NICASTRO.[1]

[1] Combustion Engineering Co., Inc. New York, N. Y. Mem. A.S.M.E.

Boeing Establishes New Aero-Engineering Course

DURING the last few years, aeronautical industries have taken their places among the major industries of the United States and require the services of many specifically trained engineers for design, construction, and operation. At the present time, the demand for highly skilled aeronautical men far exceeds the available supply, consequently, the industries are forced not only to draw inexperienced men from all branches of engineering but also to train them.

With this in mind the Boeing School of Aeronautics at Oakland, Cal., is establishing a new aeronautical-engineering course to supply the aeronautical industries with engineers who have had a maximum of experience in solving practical engineering problems during their course of study. The course will cover a period of two years, divided into four twelve-week quarters each. This is comparable to a three-year course in the average university.

A prerequisite of two years of college engineering will be required for entrance which will eliminate the necessity of including the basic sciences and engineering mathematics in the curriculum. The fundamental engineering courses, normally given in the junior year of college, will be included along with the more highly specialized courses dealing specifically with the aeronautical field.

The plant and equipment of the school are sufficient to give the type of instruction necessary adequately to train practical engineers. For example, students may assist in the designing of a complete airplane, go into the shops and take part in its construction, then have the opportunity to see it actually flown. Those students who are pilots or who are taking flight training at the school may have the opportunity actually to fly the ship which they have helped design and construct.

With this program it will be possible to turn out engineers who have had sufficient experience to enable them to be of some value to the aeronautical industries without the usual long period of apprenticeship which has proved to be highly unsatisfactory both to the individual and the organization employing him.

Instruction in aeronautical engineering will be under the supervision of Prof. E. L. Ryder, for the past two years connected with the department of aeronautical engineering at the University of Washington.

Courtesy Grand Rapids Convention Bureau

DRIVE IN GRAND RAPIDS

(A.S.M.E. Wood Industries Division to Meet at Grand Rapids. See pp. 788–789.)

American Engineering Council

The News From Washington

A.E.C. Urges a Public-Works Department

GOVERNMENT reorganization, including all of the ideas advanced for a Public-Works Department, was left in the tangled mass of unfinished business by the first session of the Seventy-Fifth Congress. It had the President's blessing, but the advantages to be gained by the elimination of duplication of work and the improvements proposed for administrative procedure were handicapped by moves to effect radical changes in fiscal and personnel administration and were discouraged by strong opposition that developed from within some of the government agencies themselves.

Council's staff conferred with the several committees on government reorganization and maintained close contact with those members of both Houses of Congress who had to do with reorganization legislation. In spite of the very friendly relationship, however, the public-works recommendation of the American Engineering Council and the President's Committee did not become an issue. No specific reason has been given for its omission from the general bills which were introduced, but it is believed to have been considered too provocative.

Assuming that engineers generally agree that most public works are well-designed, honestly executed, and administered without conscious or deliberate waste or extravagance, the Council made the following statement to the Select Committee on Government Reorganization of the United States Senate urging the establishment of a Department of Public Works for the sake of economy in the conduct of government construction business. A Public-Works Department was also recommended as an ideal medium for the coordination of our engineering and construction resources during periods of economic depression and as a more effective means of mobilization for national defense.

The Council States Its Views

Engineers believe that the President should have effective managerial authority over the executive branch of the federal government commensurate with his responsibility under the Constitution of the United States, but they are not as concerned with strengthening the Executive as they are with the larger aim of strengthening the administrative management system of the United States as a whole. They feel that the need for reorganization of the many agencies rests not only on the idea of savings, as considerable as they may be, but upon a very real need for a more economical and effective organization which could be more easily understood and controlled by the people. It is realized that the reorganization of the many units of the executive branch of the federal government is an enormous undertaking, but engineers urge reorganization under

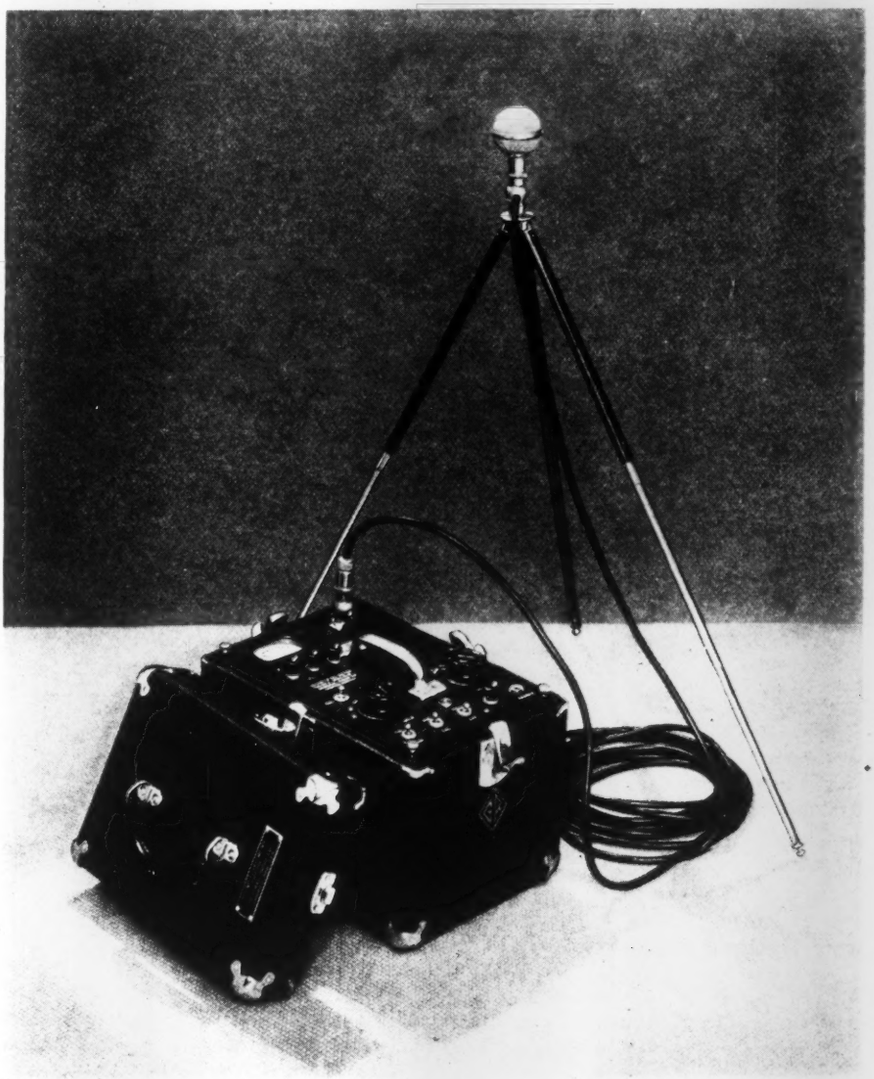
(*Continued on page 798*)

SIMPLIFY SOUND STUDIES

with this new Noise Meter

HERE is a new noise meter, portable, light weight, self-contained and inexpensive. It can be operated by anyone and gives the immediate answer to the often vexing question, "How much noise does it make?" It is invaluable in *any* noise study involved in the design or operation of mechanical or electrical equipment.

Altho only on the market for a short time, the General Radio Sound Level Meter has met with instant response from engineers interested in the noise level in automobile engines, horns, ventilators, drill presses, punch presses, milling machines, automobile bodies, mufflers, household appliances, city streets and countless other places.



The General Radio meter has an exceptionally wide range: 24 db (a *silent* countryside) to 130 db (a pneumatic road hammer). It is operated by self-contained batteries and requires no adjustment during the life of the batteries.

This new meter has these important features: standardized readings which agree with the standards set by various engineering associations; non-directional piezo-electric pick-up which is unusually sensitive and unaffected by ordinary changes in temperature and humidity; stable calibration; self - contained and portable (23 ½ pounds *with* batteries); non - microphonic construction throughout; *three* weighting networks; convenient carrying handles on both the containing case and the instrument itself.

If you have any sound level problem, this new General Radio instrument will supply the correct answer.

● *Write for Bulletin 171-K, a complete manual on the technique of noise measurements.*

THE General Radio Type 759-A Sound Level Meter is shipped complete with all tubes and batteries and is ready for immediate operation. Its price is only $195.00. Some special applications require an extension cord and tripod for the pick-up. These are sold for $9.50

GENERAL RADIO COMPANY

Cambridge, Massachusetts

BRANCHES: New York Los Angeles San Francisco

Since 1915

MANUFACTURERS OF RADIO AND ELECTRICAL LABORATORY APPARATUS

direction of the Chief Executive on the basis of standards set up by Congress to provide up-to-date management for whatever activities may be decided upon by the people.

Engineers have for many years favored the use of the merit system in personnel administration, and they now endorse the idea of expanding civil service to cover all non-policy determining positions. They recognize the civil service system as a valuable part of government management under a non-partisan Civil Service Commission and urge salary adjustments throughout the service so that the government may attract and hold in a career service men and women of the highest character and ability. Such a career is possible only when government service is concentrated and most of its positions are filled through civil service. In that way, opportunities for advancement open up to employees in the whole career system instead of the limited confines of a small service. Under such circumstances, engineers feel that direct appointments by the President should be reduced to a very small number of only the highest positions, and all other civilian positions should be filled by the heads of departments, without fixed term, through civil service with adequate tests to determine fitness.

Scope of Public-Works Department Outlined

Engineers, who have made enormous contributions to the social advancement and economic welfare of their country and to civilization, feel that they are qualified by training and experience to advise their government regarding engineering and public-works activities. On that assumption, they recommend the creation of a Public-Works Department to which the President should be authorized to transfer such major engineering and construction work for government agencies as may be practicable. Engineers believe that a Public-Works Department should be authorized to coordinate the design, construction, operation, and maintenance of all large-scale public works which are not incidental to the normal work of other departments, to act as an agent of other departments on engineering public works, to administer federal grants to national, state, and local agencies for construction purposes, and to gather information with regard to public-works needs and standards throughout the nation. They believe that a relatively small staff could and should direct such work in the hands of engineers in private business throughout the United States, without confusion and waste or the loss of valuable time.

Such reorganization should promote efficient government in all of its branches, because it is now extremely difficult even for persons charged with executive duties and legislative responsibilities to properly comprehend many of the problems that arise among scores of scattered agencies. As related functions falling in the same field or having the same general purpose could be brought into organic connection and their operations made capable of consideration, as a whole, it should be easier for the Chief Executive to formulate programs for submission to Congress; and the Congress should be able to give more intelligent consideration to legislation and reach less hurried decisions regarding appropriations. The service agencies could perform their work with more certainty; and the public could more readily comprehend the work of the government, more directly exercise that general control which should obtain under a popular government, and more easily transact business with the government's agencies.

Excerpts From Resolutions Included

Excerpts were included from resolutions by the American Society of Civil Engineers and the American Engineering Council's Assembly to the effect that both organizations would support "the enactment of suitable legislation designed to create a Federal Department of Public Works, as proposed by the President of the United States, with definite provision for excluding the Army Engineers and their river and harbor work from this Department." It was also stated that existing working organizations need not be disturbed by the reorganization process, and that all questions involving the redistribution of duties should be subject to decisions by proper authorities in the light of future experience and investigation.

Courtesy Pittsburgh Chamber of Commerce

PITTSBURGH SKYLINE

(A.S.M.E. and A.I.E.E. to Meet at Pittsburgh. See pps. 789–790.)

Positions Available

Engineering Societies Employment Service

MACHINE DESIGNER for general plant layout for manufacture of photographic film and paper. Duties will cover selecting, purchasing, and installing stills, various kinds of tanks and all kinds of piping; laying out production flow in processes; arranging equipment in buildings; handling drafting details by others; writing specifications; handling correspondence. Apply by letter. Location, East. Y-2054a.

MACHINE DESIGNER to design special equipment used in drying, coating, and other processes in manufacture of film and paper. Duties will cover selecting, purchasing, and installing stills, various kinds of tanks and all kinds of piping; laying out production flow in processes; arranging equipment in buildings; handling drafting details by others; writing specifications; handling correspondence. Location, New York State. Y-2054b.

MECHANICAL ENGINEER who is thoroughly experienced in purchasing manufactured automotive equipment as well as parts, machinery, large and small tools, and all types of ferrous and nonferrous metals and nonmetallic minerals. Must be comparatively well-known to large suppliers. Apply by letter. Location, New York, N. Y. Y-2057.

DESIGNER on automatic machinery for company manufacturing dial scales. Some electrical experience desirable. Apply by letter. Location, New York, N. Y. Y-2059.

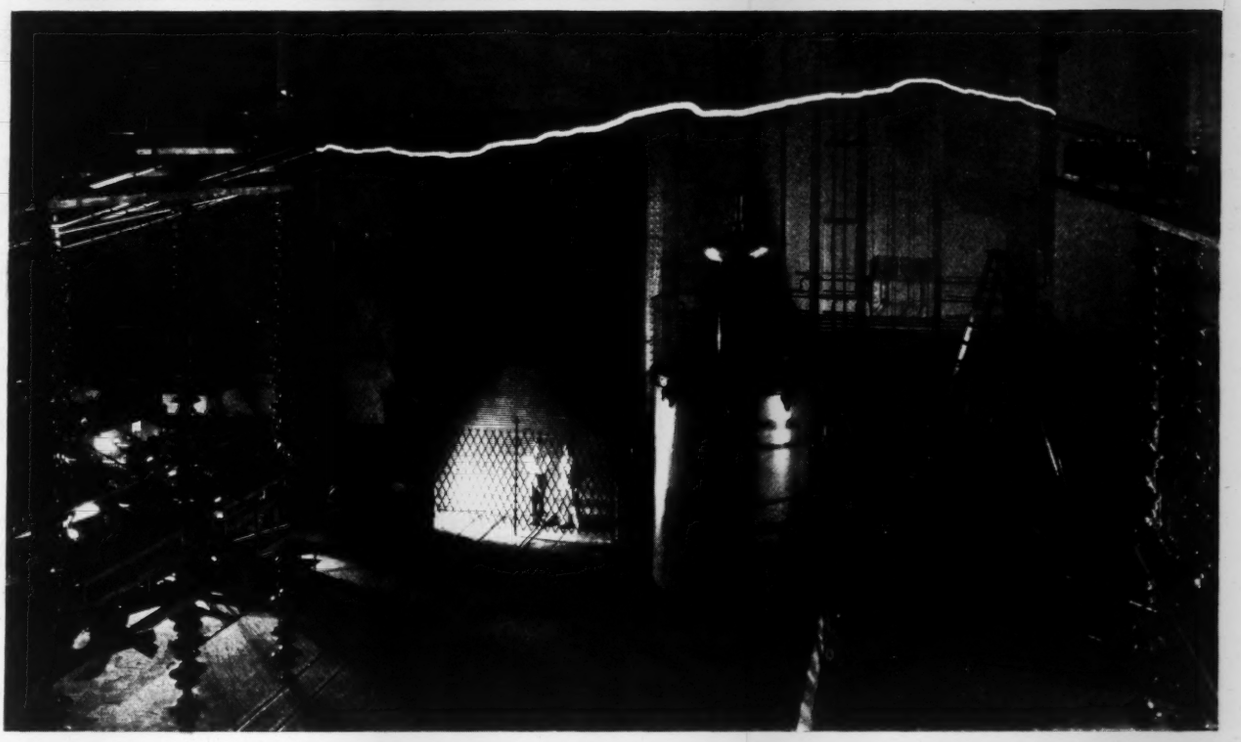
DRAFTSMAN, young mechanical engineer for development of oil burners for domestic use. Temporary. Apply by letter. Only engineer residing within commuting distance of New York, N. Y., will be considered. Y-2063.

RESIDENT ENGINEERS, graduates of well-known universities with 10 to 15 years' general industrial engineering experience, specialization in standard cost systems, management, labor incentives, general manufacturing survey work, organization, etc. Salary, $75–$100 a week. Location, New England. Y-2077.

GRADUATE MECHANICAL ENGINEER, 30–45, for development of new products in printing industry. Should have vision to recognize needed technical improvements in machinery and equipment. Apply only by letter. Location, New Jersey. Y-2097.

(Continued on page 800)

To Measure—LIGHTNING



A BLINDING FLASH—a crashing, deafening roar—and 10,000,000 volts of man-made lightning thunders through the high-voltage laboratory. In the almost inconceivably brief time of one ten-millionth of a second, there is set loose 12,500,000 kilowatts—more than fifty times the total electric power developed at Niagara Falls.

From hundreds of experiments like this, G-E engineers have developed instruments to measure lightning strokes. Instruments like the surge-crest ammeter, which has measured lightning currents as high as 160,000 amperes; instruments similar to the automatic oscillograph, by means of which flash-overs may be located on lines miles from the power-house.

From the surge of lightning to the trickle of electrons in a vacuum tube—these extremes illustrate the scope of G-E measuring activities. And in between are the hundreds of other instruments—ammeters, voltmeters, wattmeters, instruments to measure resistance, frequency, power-factor. Each is the product of years of experience in the instrument field; each design embodies General Electric's accomplishments in all branches of electrical science. Made in ranges to suit every purpose, G-E instruments are available for every need. They supply the scientific knowledge to make your electric power more dependable.

If you have a problem that involves the measurement of any quantity, remember that General Electric is HEADQUARTERS FOR ELECTRICAL MEASUREMENT.

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